JAN BAPTISTE VAN HELMONT
(1577–1644)

Carbonic Acid
in
Medicine

BY
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With the Portraits of
van Helmont, Priestley and Lavoisier

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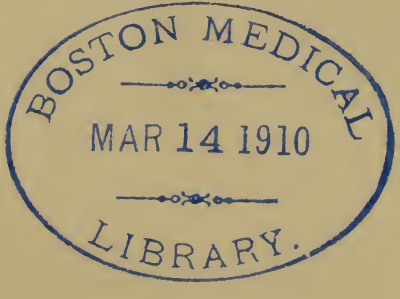

PREFACE

Among the transactions of the Congress of Balneologists which met in Berlin from March 9 to March 13, 1905, perhaps the most important were the papers read by Homberger and Fellner on the effect of carbonic-acid baths. These two papers are certainly the best which have been written on the physiological action of carbonic acid externally applied. They present investigations of Winternitz, Fellner, Homberger, and others, which furnish a scientific basis for a number of facts, thus far only empirical. These publications, of which I have availed myself, reached me just in time before I placed the manuscript of this book in the hands of the typographer.

The history of carbonic acid in medicine is very little known. At least, text-books hardly speak of it. The material for the historical sketch here given I found in great part in French and German books not translated into English. Among these was Lavoisier, "Mé-

thode de nomenclature chimique. Mémoire sur la nécessité de réformer la nomenclature de la chimie," lu à l'Assemblé publique de l'Académie Royale des Sciences du 18 Avril 1787. This precious and probably rare book I found in the New York Academy of Medicine. It had formerly belonged to the library of the New York Hospital. Some of my readers will be pleased to have their attention called to it.

In writing the chapter on the Physiology and Chemistry of Respiration I availed myself of Hammarsten, "Lehrbuch der physiologischen Chemie." Several chapters are to some extent a reproduction of papers published by me during the last twenty-two years. The observations on the value of carbonic acid in dysentery, rhinitis, vomiting in pregnancy, and the solution of the problem of curing rectal fistula without operation I am confident will be confirmed in time, in spite of misocainia, with which we have to reckon when presenting a new subject.

I desire to express my gratitude first of all to Dr. E. C. Dent, the Medical Superintendent of Manhattan State Hospital, Wards Island,

for his courtesy in permitting me to introduce carbonic-acid-gas baths in his institution, and to the members of the staff of Manhattan State Hospital, among these especially my friend Dr. R. C. Kemp. They all aided me generously in my investigations. I wish to express my thanks also to my colleagues of the New York Post-Graduate Medical School: Drs. Thomas E. Satterthwaite, Duncan Macpherson, and Frank Newton Irwin, who took an active interest in my modest labors.

Friends have asked me how I came to devote myself to the study of carbonic acid. This question always brought to my mind an anamnesis: the memory of my dear old friend Mr. Thomas Warker who early excited my interest in it. During the last decades of his life he had been industrious and indefatigable in inventing contrivances for the application of carbonic acid. His personal relations to Demarquay had inspired him with enthusiastic faith in the future of carbonic acid in medicine.

A. Rose.

New York, August 20, 1905.

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CHAPTER I

THE PHYSIOLOGY AND CHEMISTRY OF RESPIRATION

Carbonic acid is a constant constituent of the animal organism, the minor portion being supplied by the atmosphere. Absorption of carbonic acid from the atmosphere is partly due to the respiratory function of the skin. Abernethy (1764–1831) already had demonstrated that the skin is a vast respiratory surface; it is true it can not be compared with the lungs, but it is nevertheless very efficient. Abernethy's experiments to find the degree of absorption of different gases by the skin show that, after oxygen, carbonic acid is the most absorbable.

Carbonic acid is taken up also through nutrition, but the larger part is derived from the tissues and the blood, and forms one of the

most important end-products of oxidation and tissue metamorphosis. It develops the effects of a weak acid as well as those of an excitant and paralyzing agent, similar to alcohol. It enters the blood in the capillary circulation from the tissues in which it is formed.

The gases occurring in the blood under ordinary physiological conditions are oxygen, carbonic acid, and nitrogen. The latter is present only in minute quantity and seems to play no important rôle in the vital processes, its quantity in different parts of the circulation being approximately the same.

The amounts of oxygen and carbonic acid present differ, not only in the blood derived from various parts of the circulation, but also in their correspondence to the rapidity of the blood-current, the different temperatures, rest, labor, etc.

According to Setschenow, oxygen is contained in the arterial blood of man to the amount of 21.6 per cent. by volume. The amount carried by the venous blood differs. Ludwig and Szeltcow found 6.8 per cent. of

oxygen by volume in the venous blood of non-active muscles, and still smaller quantities in that of those in action. Oxygen is entirely absent, or present only in traces, in the blood of the asphyxiated. Zuntz states that the venous blood of the right heart contains on an average 7.15 per cent. less of oxygen than the arterial blood.

The proportion of carbonic acid contained in the arterial blood is usually forty per cent. by volume, but varies between thirty and forty per cent. It always corresponds exactly, or very nearly, to the amount contained in the air of the alveoli. Every change in the composition of the alveolar air must be followed by a corresponding change in the tension and the absolute quantity of the carbonic acid in the arterial blood. Again, the carbonic-acid tension of the arterial blood affects primarily the diffusion between the blood and the tissues; hence any variation in the proportion of carbonic acid in the alveolar air, when continuing for some time, will cause a corresponding change in the proportion of the carbonic acid

in the blood and tissues, where it is always found in considerable quantities.

The proportion of carbonic acid contained in the venous blood varies still more. According to Zuntz, the venous blood of the right heart contains 8.2 per cent. of carbonic acid more than the arterial blood. The average quantity is about forty volumes per cent. In the blood of the asphyxiated Holmgren found even 69.21 volumes per cent. of carbonic acid.

Almost all the oxygen in the blood is loosely held by the oxyhemoglobin, and only a small portion—0.26 per cent.—is absorbed by the plasma or serum. The circulating blood does not appear to carry oxygen entirely up to the point of saturation. Of the carbonic acid found in the blood, the smaller portion — according to the examinations of Alex. Schmidt, Zuntz, and L. Frederiks at least one-third—is contained in the blood-corpuscles, by far the larger quantity being carried by the plasma and serum.

The carbonic acid in the blood-corpuscles forms a loose chemical union, first with the

alkalies which there enter into combination with phosphoric acid, oxyhemoglobin, or hemoglobin and globulin; and, secondly, with the hemoglobin itself. The red blood-corpuscles do not contain enough alkali phosphate to be of importance in the formation of carbonic acid. In all probability the diphosphates present are converted into monophosphates and alkali carbonates when partial pressure of carbonic acid is increased, while, when the same is diminished by the preponderance of phosphoric acid, a reformation of diphosphates takes place and carbonic acid is again liberated. It is generally conceded that the blood-coloring matters, especially oxyhemoglobin, which by its presence *in vacuo* with bicarbonate of soda causes the liberation of carbonic acid, act similarly to acids; and, inasmuch as the globuli have a similar action, they may also occur in the blood-corpuscles as alkali compounds. The alkalies of the blood-corpuscles die when thus found in combination with phosphoric acid, carbonic acid, and such parts of the corpuscles—*e.g.*, the coloring-matter—as act similarly to acid. In

the presence of a preponderance of or of a greater partial pressure of carbonic acid, bicarbonates may be formed at the expense of the diphosphates and the alkali compounds just mentioned; while, when partial pressure of carbonic acid is lowest, a reformation of the diphosphates and the alkali compounds will take place, and carbonic acid will be liberated from the bicarbonates.

The investigations of Setschenow, Zuntz, Bohr, and Torup, however, make it appear probable that hemoglobin itself, even in the presence of alkalies, can loosely bind carbonic acid. Bohr found, in addition, that the curve showing dissociation of carbonic-acid hemoglobin, and that showing increase or decrease of carbonic acid in the blood, essentially correspond; and hence Bohr and Torup ascribe considerable importance to the hemoglobin itself, rather than to its alkali compounds, in the formation of carbonic acid in the blood. Moreover, hemoglobin possesses the ability to absorb the two gases, oxygen and carbonic acid, both independently of each other and simulta-

neously. Bohr believes that the granules of coloring-matter absorb the oxygen and that the carbonic acid is bound by the albumin component. The main amount of carbonic acid in the blood is found in the plasma or serum. It is more abundant in the serum than in the other constituents. We find the carbonic acid in the serum and blood-plasma distributed as follows: 1. A part is simply absorbed. 2. Of the remainder the larger part is in loose, the smaller part in firmer, chemical union.

The quantity which is simply absorbed can not be exactly determined. Setschenow estimates that in the serum of the dog it forms about one-tenth of the entire carbonic acid contained in the blood. The quantity of carbonic acid in firm chemical combination must be determined by the amount of alkali carbonates; it is, however, not exactly known, inasmuch as the alkalies of the blood are not only associated with carbonic acid, but also with other components, especially with the albumins.

Part of the loosely bound carbonic acid of the serum which can be separated by the ex-

haust-pump is found as bicarbonate; in fact, alkali is the most essential and most important component uniting with carbonic acid in the blood-serum as well as in the blood itself.

The amount of the carbonic acid in the blood lessens with a lessening amount of alkali. Such is, for instance, the case when poisoning with mineral acid takes place. Thus Walter found only 2.3 volumes per cent. of carbonic acid in the blood of rabbits, into the stomach of which he had introduced hydrochloric acid. It seems as if, during the comatose stage of diabetes mellitus, the alkali of the blood was saturated to a large extent by acid combinations (oxybutyric acid). Minkowski found only 3.3 volumes per cent. of carbonic acid in the blood of a comatose diabetic.

The oxygen of the blood exists in dissociable combination with the hemoglobin; and this combination, the oxyhemoglobin, depends on a certain partial pressure of the oxygen, which pressure varies with the temperature. The same is the case with carbonic acid in the blood, that contained in the corpuscles as well

as that in the plasma; it exists there in combinations which depend to a high degree on partial pressure. As we see from the foregoing, quite a number of elements act together with carbonic acid, making it apparently impossible to decide the quantitative part of each single factor in the entire effect.

It is of great importance to know the amount of tension of oxygen and of carbonic acid in the blood, in order to decide the question of the exchange of gases between the blood and the alveolar air on the one hand, and the blood and the tissues on the other; and especially to decide how far this exchange of gases takes place under the law of diffusion, and how far other forces may be active.

The change of gases in the tissues, the so-called internal breathing, takes place in the following manner: Oxygen leaves the capillaries to enter into the tissues, and simultaneously the main mass of the carbonic acid of the blood which is derived from the tissues leaves the latter and enters into the capillaries. The change of blood in the lungs, the so-called external

breathing, is the taking up of oxygen by the blood from the air in the lungs, and giving up of carbonic acid to the latter.

These processes of the double gas exchange are not yet sufficiently explained. The question which is yet to be solved is: Does the exchange of these gases take place in consequence of the difference between their tensions in the blood and in the air in the lungs and the tissues respectively, or through the laws of diffusion, or are there other factors in operation?

Oxygen in the blood exists for the most part as oxyhemoglobin. To find the tension of oxygen in the blood it is necessary, first, to consider the laws of dissociation of oxyhemoglobin. G. Huefner and others have examined this dissociation under temperature of 35° and 39° C. (95° and 102° F.), and their experiments have shown that when the partial pressure of oxygen is reduced to the level of the pressure existing in atmospheric air, there is no marked influence noticed in regard to the quantity of oxygen, either in the blood or in a correspondingly concentrated oxyhemoglobin solution. The investigators—

Paul Bert, Herter, and Huefner—have found by their experiments that the tension of oxygen in the arterial blood at the normal temperature of the body is equal to an oxygen partial pressure of 75–80 mm. of mercury. The tension of the oxygen of the air in the lungs was compared with these figures.

Numerous investigations in regard to the composition of the inspired atmospheric air as well as the air of expiration have been published. These two kinds of air have on an average, at 0° C. and under pressure of 760 mm. of mercury, the following composition expressed in volumes per cent.:

	Oxygen.	Nitrogen.	Carbonic Acid.
Atmospheric air.....	20.96	79.02	0.03
Air of expiration	16.03	79.59	4.38

The partial pressure of the oxygen in the atmospheric air—the barometer having the average 760 mm.—corresponds with a pressure of 159 mm. of mercury. The loss in oxygen which the air of inspiration sustains during respiration is therefore 4.93 per cent., while

the air of expiration contains about one hundred times as much carbonic acid as the air of inspiration.

For the exchange of gases in the lungs the composition of the alveolar air is of paramount significance. Of the composition of this air in man we possess no positive but only approximate calculations; the probable amount of carbonic acid contained in the alveolar air has been set down at 5.44 per cent., the amount of oxygen as 14.96 per cent.—the latter corresponding with a partial pressure of 114 mm. of mercury.

Bohr believes that the lungs take an active part in the absorption of oxygen; other authors have controverted this assumption. The present state of the question is such that we can not produce sufficient reasons for abandoning the view as yet generally adopted, viz., that the entrance of oxygen into the lungs takes place simply by means of diffusion; and further, after what has been said of tension and dissociation of oxygen in the blood, it is to be supposed that the amount of oxygen in the blood, at least

within certain limits, does not specially depend on the amount of oxygen in the atmospheric air. Indeed, it is known that the increase of the oxygen pressure, even to the strength of one atmosphere, has no essential influence on either the amount of oxygen taken into the lungs or the amount of carbonic acid which is exhaled.

Paul Bert found that animals placed in pure oxygen under a pressure of three atmospheres, or in ordinary atmospheric air under a pressure of fifteen atmospheres, have convulsions and quickly perish; whence it would appear that oxygen at high tension is inimical to life.

This oxygen intoxication is characterized by an extraordinary reduction of the consumption of oxygen and by the formation of carbonic acid. All organisms, animal as well as vegetable, succumb alike. Even seeds of plants which in general are possessed of great power of resistance lose for a certain time, when exposed to oxygen under high pressure, their germinative power. Oxygen exerts a deleterious effect on the different organisms when they are

exposed to it for a greater length of time, even at a tension far below the one which kills quickly. Bert observed that the development of eggs and the metamorphosis of insects were injured by a long stay in pure oxygen under ordinary pressure. When we inhale pure oxygen its consumption and the formation of carbonic acid become diminished. The deleterious effects of excess of oxygen and overaccumulation of carbonic acid when occurring together cause an animal to perish even when neither of the two gases by itself is present in a dangerous dose.

Pflueger, in order to bring the remarkable effects of compressed oxygen nearer to our understanding, has called attention to its analogous behavior toward phosphorus. In pure compressed oxygen phosphorus does not give light and does not absorb oxygen; as soon, however, as sufficient nitrogen is added, or the pressure is diminished, the production of light takes place and the oxygen becomes absorbed.

Altho carbonic acid is a matter for excretion and life can be continued only when this gas is

eliminated from the system regularly by rhythmically recurring respiration, it would be erroneous to deny it any further rôle in the economy of the system. The carbonic acid in our system, with its normal quantitative changes, seems to be necessary to excite important vital functions, especially respiration and circulation. The symptoms of intoxication making themselves noted at the respiratory pneumogastric and the vasomotor centers when excessive quantities of the gas have been inhaled may be explained, to some extent at least, as suggestions of normal physiological processes.

The tension of the carbonic acid in the blood has been calculated in various ways by Pflueger and his pupils, Wolfberg, Strassburg, and Nussbaum. According to Strassburg, it is 2.8 per cent. of one atmosphere, corresponding to a pressure of 21 mm. of mercury. Nussbaum found in the blood from the right heart a carbonic-acid tension of 3.81 per cent. of one atmosphere, corresponding to a pressure of 28.95 mm. of mercury. Bohr, by his experiments on carbonic-acid tension, arrived at other figures.

A comparison of the carbonic-acid tensions in the blood and in the tidal air showed in several instances a greater carbonic-acid pressure in the air of the lungs than in the blood, and the maximum of the difference was 17.2 mm. in favor of the air of the lungs. The alveolar air contains more carbonic acid than the air in the bronchi; therefore Bohr's experiments show that the carbonic acid in the alveoli has moved against the higher pressure. It has been assumed that the oxygen has a certain significance in regard to the elimination of carbonic acid in the lungs. Some attribute to oxygen the power to drive the carbonic acid out of its combinations in the blood. Experiments seem to show that the oxygen from the alveoli, entering into the blood, intensifies the tension of carbonic acid, and hence that the oxygen becomes an auxiliary factor for the elimination of carbonic acid. This assumption, however, has met with opposition, and the question is yet an open one.

Concerning the elimination of carbonic-acid gas in the lungs, we are still without convin-

cing reasons for abandoning the generally adopted view, according to which the carbonic-acid gas coming from the blood enters the lungs simply by the law of diffusion. There is a considerable difference of pressure in regard to the oxygen in the blood and the oxygen in the tissues, and, owing to this difference of pressure, the tissues are supplied with the necessary amount of oxygen. Quite the opposite is the case with carbonic acid; the tension is higher in the tissues than in the blood, and all the investigations thus far made have produced no evidence against the assumption that carbonic acid from the tissues enters the blood simply by the laws of diffusion.

Considering even superficially the quantities of oxygen in the blood, it appears at once plain enough that the main amount can not have been absorbed physically; for the serum of the blood, as a solution of different substances, absorbs less oxygen than pure water. It can absorb hardly 0.3 volume per cent. of oxygen from the atmospheric air at the ordinary temperature of the body. In reality, however,

arterial blood holds not less than seventy times this quantity of oxygen.

The same law applies to carbonic acid, the larger part of which, as has been shown, is held in chemical union in the blood and can not to any great extent be absorbed physically. The partial pressure of the carbonic acid in the blood is much too small to allow of the gas being simply absorbed. The carbonic-acid tension in the venous blood of the dog is 41 mm. of mercury. This would permit 2.5 volume per cent. of carbonic acid to be physically absorbed therein, while, according to the same reasoning, arterial blood would show only about half that amount. In reality, however, the venous blood contains forty-six and the arterial thirty-eight volume per cent. of the gas.

A comparison of the gases of the arteries with those of the veins is of great importance, because it furnishes directly the evidence that real processes of combination do not occur to any considerable extent in the lungs, but that almost the whole amount of oxygen which has entered the lungs can be separated from the

blood of the arteries by means of the exhaust-pump.

The mass of inspired air has to be divided, in regard to its action on the renewal of the air in the alveoli, into two parts. A certain amount remains in the upper air-passages and is removed again by expiration. The rest enters into the alveoli to mix with the air which is already there. On account of the smallness of each single infundibulum, it is likely that the diffuse mixture of old and fresh air takes place instantaneously, while the bronchial tubes are too long to allow the exchange of their gases with those of the alveoli by diffusion, which could hardly be accomplished in the time between two respirations.

The next process in respiration is that air from the alveoli takes the place of the expired contents of the bronchi, and only when the extent of the expiration exceeds in volume that of the air-passage will alveolar air pass out directly. The movements of respiration, therefore, can have but little success when the volume of each expiration does not exceed that of

the air-passages—that is, does not more than exhaust the contents of the air-passage. Thus a very superficial breathing will only insufficiently ventilate the alveoli, even tho the frequency of respiration is increased. The residual air, which during lifetime can not be expelled from the lungs, has been calculated by Vierordt to be from 1,230 to 1,640 c.c.

The expired air is richer in carbonic acid and poorer in oxygen in proportion as the larger part of it comes from the alveoli—that is to say, the more profound the expiration.

CHAPTER II

HISTORY OF THE USE OF THE CARBONIC ACID IN THERAPEUTICS

THE application of carbonic-acid gas for therapeutical purposes can be traced to the earliest times. We all have read of the stone of Memphis, which stone was pulverized, dissolved in vinegar, and applied to parts of the body in order to anesthetize them. Dioscorides and Plinius speak of this stone. But exact observations of the gas were not made before the seventeenth century.

Mineral springs, with their large volume of carbonic-acid gas dissolved in water, have served for therapeutical purposes long before carbonic acid had been demonstrated. They often present remarkable appearances when relieved from subterranean pressure, by losing their gases with more or less rapidity, according to the tension to which they had been sub-

jected. Some of them issue from the earth with rumbling, gurgling, or hissing noises; others do so only at regular intervals, and rise to a height of from twenty to forty feet; some ascend from the bottom of the sea, of lakes, and of rivers; others appear many thousand feet above the level of the ocean; some break at a boiling heat through a crust of ice and snow; others issue with icy coldness near shrubs and flowers; some destroy vegetation in their immediate neighborhood, while others penetrate and cover organic structures with calcareous incrustations and preserve them.

Such phenomena were replete with wonder and attracted the attention of philosophers from an early period. Supernatural properties were ascribed to the springs. Strange theories were propounded regarding their origin, and wonderful tales and fables were current of their curative powers.

Strabo relates that the springs of Hierapolis imparted a red color to the roots of trees and shrubs, and that the juices of the latter, when mixed with the water, produced a purple liquor

which was used for dyeing wool. We shall see how this reaction of carbonic acid was interpreted by Hoffmann, who lived in the seventeenth century. Philostratus, when speaking of the sanguinary battle which the Greek army fought with Telephus, on the banks of the river Caicus, states that the wounded Greek soldiers who resorted to Agamemnon's spring, near Smyrna, were all restored. According to Herodotus, a spring in the country of the Ichthyophagi (fish-eaters) prolonged life to beyond one hundred and twenty years. A spring in Chios caused insanity; another in Magnesia improved the voice of singers; and the spring of Alysson was a specific for hydrophobia. The springs of Lethe and Mnemosyne are often mentioned in classical literature; the former gave oblivion and the latter memory.

Little is mentioned of mineral springs in the Old Testament. According to the Genesis, Anah, the father of Esau's wife, discovered some thermal springs in the desert; and in the second book of Kings we find mention made of a spring at Jericho which made the ground

barren, and was made wholesome by the prophet Elisha throwing salt into it. But from the New Testament we learn that the Jews, before Christ, used thermal waters extensively. "There lay a great multitude of impotent folk, of blind, halt, and withered, in the porches of the lake Bethesda, by the sheep-market at Jerusalem, waiting for the moving of the waters; and whosoever first after the troubling of the water stepped in, was made whole of whatsoever disease he had." This water had a reddish-brown color, from a sediment of ochre probably deposited by the escape of carbonic-acid gas; sulfur was also found in the mud, and the more rapid disengagement of carbonic acid and sulfureted hydrogen when the water was stirred up may account for its increased curative power at such time.

Mineral springs play an important part in the religion of the ancients. The priests of Æsculapius erected temples to the god of medicine in the vicinity of mineral springs. They were not only provided with theaters and places of amusement as our fashionable modern water-

resorts, but also with hospitals and medical schools for the instruction of students. The most important of these were the springs of Nauplia, in the sacred grove of Æsculapius. They have been described by Pausanias, and from the remains of their structures we can judge of their former greatness. The water of Nauplia has been analyzed by Landerer and found to contain carbonic acid.

The Castalian spring had a temperature of only 33° C.; in this spring Pythia had to bathe before ascending the tripod in the steaming cave in Apollo's oracle at Delphi. There are copious exhalations of carbonic-acid gas in that cave, and from the short and incoherent sentences which the priestess uttered in her excitement and paroxysms the prophecies were drawn. Such were also the gas-springs of Dodona, the most ancient oracle of the Greeks.

Paracelsus (1493–1541) made use of carbonic-acid gas for therapeutic purposes, calling it Spiritus sylvester. He knew that the gas produced by burning charcoal is identical with that developed when limestone is heated to a

high degree. Paracelsus's full name was Philippos Aureolus P. Theophrastus Bombastus Paracelsus ab Hohenheim. Paracelsus examined most of the chemical products with which he became familiar as to their therapeutic properties, saying that the true usefulness of chemistry was not to make gold, but to prepare healing remedies. For his labors in this direction, we can hardly overestimate his merits. Many medicines which are highly valued to this day were discovered and introduced by him. The internal administration of mercury in different forms, and several preparations of lead, of antimony, of sulfur, of copper, and of iron were first taught by Paracelsus. With his method of extracting from medicinal plants the essence—the quintessence, as he called it—and prescribing this essence instead of the whole plant, he was far ahead of his time.

Jan Baptist van Helmont (1577–1644), who can be regarded as one of the greatest chemists who preceded Lavoisier, was the founder of pneumatic chemistry. He was the first who used the word gas as a generic name for all

elastic aeriform fluids, in order to distinguish them from atmospheric air. He paid much attention to the study of gases, and showed that they entered into the composition of the atmospheric air. He first gave a description of carbonic acid, which he called gas sylvester, and described its development, when the acid is brought into contact with limestone or potash, at wine and beer fermentation, during putrefaction, its appearance in the stomach, and showed that it was contained in the mineral water of Spa, that it was rising from the ground in some places, for instance, at the dogs' grotto near Naples. However, his distinction of the different kinds of gases was still imperfect; he knew no means to handle the different gases he had developed. Under the name of gas sylvester, which he sometimes designates by the term gas carbonicum, he understood principally carbonic acid.

Jan Baptist van Helmont, a Brabant nobleman, was born at Brussels in the year 1577. In Louvain he attended the ordinary philosophical course until his seventeenth year, then stud-

ied with the Jesuits mystic philosophy and even magic, later on theology and especially mysticism. This led him to the decision to renounce the world for a religious life with devotion to good works. He transferred his large estates in favor of his sister. In order to make himself the more useful, he studied medicine. At first Hippocrates and Galen were his guides, until he began to doubt their system and to study the works of Paracelsus.

From these works he became so greatly inspired that he now exerted all his powers to combat Galen's system, to develop further the chemicomedical theory, in order to establish more firmly the reformation in medicine instituted by Paracelsus. He traveled a long time in France and Italy and acquired great fame as physician. Returned to his native country, he lived a retired life, occupied with chemical investigations. van Helmont had an advantage over Paracelsus on account of his profound, scientific education, but he always refers to Paracelsus with highest esteem. There exists a certain similarity of characters between

the two: both were inspired enthusiastically by a wish to work for a total reform in medicine. van Helmont still believed in the possibility of metamorphoses of metals, but with him begins our knowledge about the gases. It is true that the fact that there exist aeric elements which differ from the ordinary atmospheric air was known before his time, but it was Helmont who pointed out the way in which these elements could be distinguished exactly, and it was Helmont who showed how these elements found in nature could be artificially produced, how thereby one can draw conclusion as to their origin.

He was one of the men with new ideas who had to combat with misocainia. Because he wrote against a certain sympathetic remedy, he was taken before the Archbishop of Mecheln and punished with two years' imprisonment; he had denied the healing power of religion. His colleagues called him all sorts of names because he was opposed to blood-letting, the universal remedy for almost all diseases at those times. Gui Patin wrote the following necrology: "van

Helmont étoit un méchant pendard flamand, qui est mort enragé depuis quelques mois. Il n'a jamais rien fait qui vaille. J'ai vu tout ce qu'il a fait. Cet homme ne meditoit qu'une medicine toute de secrets chimiques et empiriques, et pour la renverser plus vite, il l'inscrivoit fort contre la saignée, faute de laquelle pourtant il est mort frénétique."

van Helmont was an exact observer, which shows itself in other works of his not concerning the gases. What characterizes him especially as representative of the era in which he lived, is the application he made of his chemical knowledge to physiology, pathology, and therapy. He directed his attention to chemical properties in the human system, showed that the most important functions of the body were in relation to the acid or alkaline condition of its fluids and to processes of fermentation.

van Helmont, however, did not consider digestion an exclusively chemical process. Inclined to spiritualism — many phenomena in nature, as thunder, earthquake, rainbow, etc.,

he took for voices or actions of different spirits —he assumed that there was a special spiritual regent in man, whom he called Archeus, as Paracelsus already had taught. By Archeus he understood the involuntary functions in man, among them digestion. The Archeus, he believed, had his abode in the stomach. Therapeutically it was his aim to influence Archeus, either to calm or to animate him, as the case might be. Notwithstanding these views, he has done a great deal to establish chemical principles in the preparation of medicines, a great deal to unite chemistry with medicine, a work which had been begun by Paracelsus.

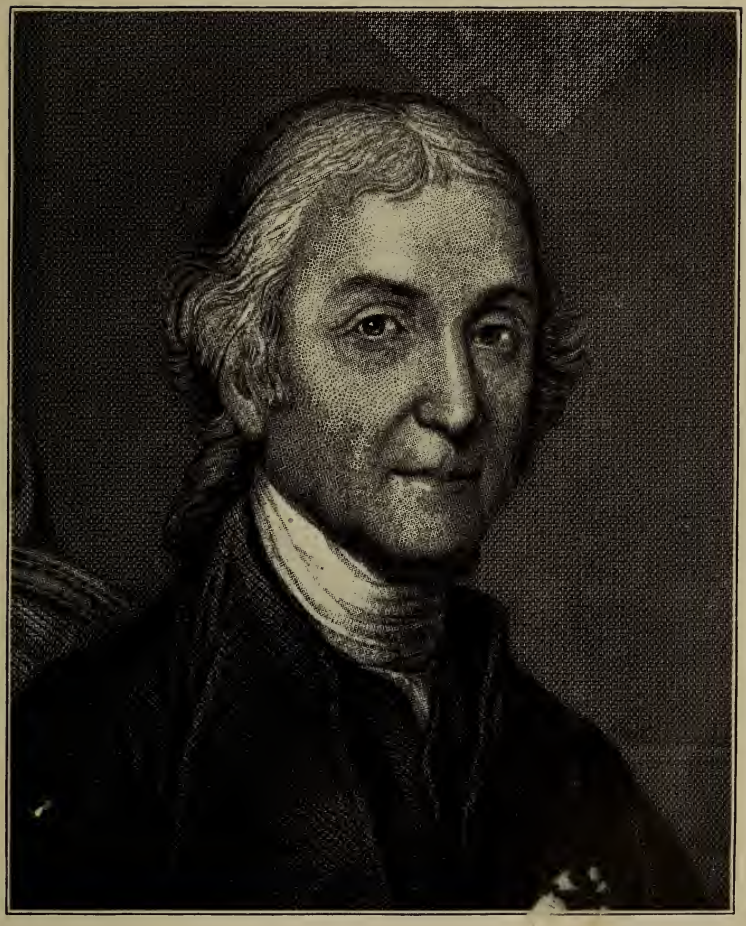
Robert Boyle (1627–1691) confirmed the discoveries of Paracelsus and van Helmont and showed how to separate and how to handle gases, but he was not aware yet that carbonic acid and hydrogen were essentially different.

Friedrich Hoffmann (1660–1742), who was in correspondence with Robert Boyle, discovered some qualities of the gas contained in mineral springs, and called it spiritus mineralis. Observing that when in watery solution it

would color certain vegetable matters red, he judged that it was a feeble acid.

Joseph Black (1728–99) was another great promoter of the study of chemistry. His important experiments with carbonic acid demonstrated its combination with alkalies. He assumed that it existed in solid form in alkalies, and called it fixed air. He supposed that it was produced by the act of respiration, proved that it is absorbed by caustic alkalies, and disengaged again under effervescence when acid is made to act upon the combination.

Joseph Priestley, born March 13, 1733, educated for the Christian ministry and became a minister in the year 1755, had been a great theologian, entangled a good deal in sectarian polemics. A study of his life gives an idea to what extent human passion was excited in England on account of difference of opinion in religious questions and what cruel prejudices existed. While prominent as a theologian he was more notably a man of science, and chiefly notable as a chemist and the discoverer of oxygen. His fuller interest in science dates from 1758,



JOSEPH PRIESTLEY
(1733–1804)

when he bought a few scientific books, a small air-pump, an electric machine, and other instruments, with the help of which he made experiments for his pupils at Nantwich as well as for his own amusement and that of his friends. During his visit to London, in January, 1766, he met Richard Price, Sir William Watson, John Canton, and Benjamin Franklin. Franklin encouraged him to undertake the "History of Electricity." The book drew him into a large field of original experiments. Franklin and Canton corrected the proofs and it was published in 1767. Priestley's electrical work shows him at his best, altho the discoveries contained therein are of less importance in the history of science than his later discoveries in chemistry.

After 1770 he practically abandoned the study of electricity for that of chemistry, to which he had been led incidentally. He had attended a course of chemical lectures given in Warington Academy by Dr. Turner, of Liverpool. He admitted that he knew very little of chemistry at the time when he began his exper-

iments; he was possessed of no apparatus, and had scarcely the means of procuring any, but he attributed his success to the ignorance which forced him to devise apparatus and processes of his own. In his memoirs he says:

"If I had been previously accustomed to the usual chemical processes I should not have so easily thought of any other, and without new modes of operation I should hardly have discovered anything materially new."

One of the earliest pieces of apparatus which Priestley devised is the well-known pneumatic trough—a simple enough piece of chemical furniture certainly, but one that required a considerable amount of experimenting. He began his chemical work by attacking the problem of combustion, the solution of which created the science of modern chemistry. He was led to study gases by watching the process of fermentation in a brewery next to his house; and in March, 1772, he read his first paper, "On Different Kinds of Air." This paper, inspired by the work of Stephen Hales, of Joseph Black, and of Cavendish, marked an epoch in

the history of the science. Priestley here set forth improvements in the methods of collecting gases, and especially the use of mercury in the pneumatic trough, which enabled him to deal for the first time with gases soluble in water. He announced the discovery of marine acid air (hydrochloric acid) and nitrous air (nitric oxid). He showed that in air exposed over water one-fifth disappears in processes of combustion, respiration, and putrefaction, and that plants restore air vitiated by these processes, and that no known gas conducted electricity.

The paper also contained a proposal to saturate water with carbonic acid under either atmospheric or increased pressure, which has led to the creation of the mineral-water industry. Of this means of making "Pyrmont water" (which he described in a pamphlet in June, 1777), he wrote: "I can make better than you import, and what cost you five shillings will not cost me a penny." Priestley likewise described the preparation of pure nitrogen, a gas to which he gave the vague name of phlogisticated air, only recognizing it later

as a distinct species. Priestley noted, without comment, that he had produced two other gases, which were subsequently recognized as carbonic oxid and nitrous oxid, and that he had disengaged from niter a gas which was later on recognized as oxygen. The paper received the Copley medal of the Royal Society (November 30, 1773), and was at once abstracted at length by Lavoisier and criticized by him. Henceforth Lavoisier acted as a sieve to separate the inaccurate work and conclusions of Priestley from the accurate.

From 1774 to 1786 Priestley published six successive volumes of researches on air. The first volume records the discovery of alkaline air (ammonia gas) and dephlogisticated nitrous air (nitrous oxid), and the synthesis of sal-ammoniæ, as well as his first general view of the current hypothesis of Becker and Stahl—that fire is decomposition, in which phlogiston is separated from all burning bodies. At various periods Priestley identified phlogiston with electricity and with hydrogen. But his whole scientific energies from this time forward were

devoted to the upholding of the phlogistic theory, which his own experiments (and their completion by Cavendish) by a strange fate were destined in the hands of Lavoisier completely to overturn.

On August 1, 1774, at Lansdowne House, Priestley discovered oxygen. By the heating of oxid of mercury he obtained what was to him a new gas, in which a candle burned vigorously. He later on found it purer than ordinary air, *i.e.*, to support respiration, as well as combustion, better, and called it dephlogisticated air. From its property of yielding acid compounds this gas was named oxygen by Lavoisier at a later date. As it both came from the atmosphere and would also be produced by heating certain metallic nitrates, Priestley concluded that the air is not an element, but consists of the nitrous (nitric) acid and earth, with so much phlogiston as is necessary to its elasticity. Priestley's great discovery of oxygen contained the germ of the modern science of chemistry, but, owing to his blind faith in the phlogiston theory, the

significance of the discovery was lost upon him.

Priestley made the first public announcement of his discovery of oxygen in a letter to Sir John Pringle, dated March 15, 1775, which was read to the Royal Society on May 25. But while in Paris, in October, 1774, Priestley, according to his own account, spoke of the experiments he had already performed, and of those he meant to perform, in relation to the new gas. Fifteen years later—in the 1790 edition of "Experiments on Air"—Priestley declared specifically that he told Lavoisier of his experiments during his visit to Paris.

There is no doubt that immediately after that date Lavoisier made oxygen for himself, and in May following published the first of a long series of memoirs, in which he used his experiments to explain the constitution of air, combustion, and respiration, the Greek idea of the conservation of matter, thus founding chemistry on a new basis. Priestley refused to accept Lavoisier's sagacious views.

The centenary of Priestley's discovery of

oxygen was celebrated in Birmingham and in Northumberland, Pa., on August 1, 1874, but there is some divergence of opinion as to who is entitled to the full credit of the original discovery. Altho Priestley was in possession of the gas before November, 1771, it is admitted that Karl Wilhelm Scheele, the Swedish apothecary, working quite independently, first recognized it as a *distinct species* before 1773; but Scheele did not publish his researches until after Priestley.

In November, 1774, Priestley discovered vitriolic acid air (sulfur dioxid), and before November, 1775, continuing an investigation by Scheele, fluor acid air (silicon tetrafluorid). This completes the list of Priestley's great discoveries of gases, nine in all.

Priestley's memoir on respiration, read in January, 1776, in which he regards respiration as a true phlogistic process, was not original in idea, but was acknowledged by Lavoisier as the starting-point of his own work on the subject, published in the next year. In the spring of 1778 Priestley returned to the important re-

searches on vegetable physiology of 1772, and discovered that oxygen is given off in the light from the green leaves. He did not publish his observation until 1781. Meanwhile John Ingenhousz had published the main facts in 1779.

In 1781 Priestley decomposed ammonia by means of the electric spark. In the same year he continued, with John Warltire, of Birmingham, certain observations of the latter in 1777 on the burning of hydrogen. Priestley, Cavendish, Warltire, and James Watt found that water was not an element, but a compound of dephlogisticated air and phlogiston. A controversy arose as to the relative claims of Watt and Cavendish with regard to priority, which Priestley might have settled but did not.

In 1785 Priestley made an admirable series of quantitative experiments on the oxidation of iron and the reduction of the oxid by hydrogen, with formation of water. In the condensed edition of his works, published in 1790, he described interesting experiments on the thermal conductibility of gases, which he found to

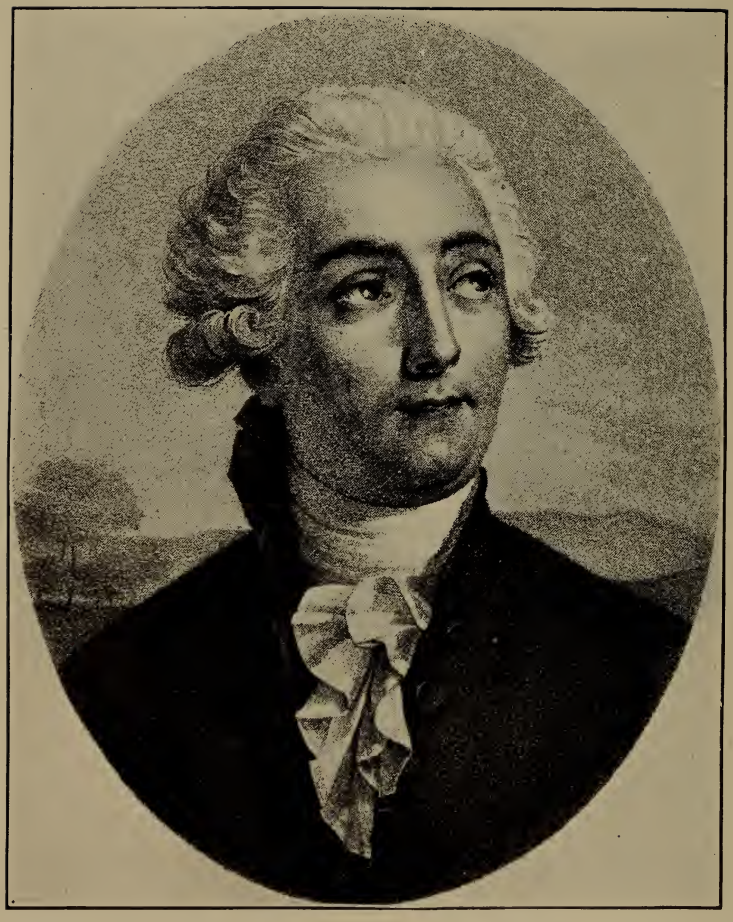
be much the greatest in the case of hydrogen. In 1796 Priestley published his considerations on phlogiston, adhering to his error. He created quite a controversy, which was continued, mainly in America.

The French Revolution excited passionate controversy in England, and Priestley was on the side of the revolutionists. In 1791 the anniversary of the capture of the Bastille was observed in Birmingham by a dinner at which he was not present and with which he had nothing to do. But the mob wished to testify by some signal deed their abhorrence of the un-English notions propounded at the dinner, and therefore burned down Priestley's chapel and house. Before the deed was done they waded knee deep in torn manuscripts. The blow was a terrible one. Priestley and his family had escaped violence by timely flight, but every material possession he valued was destroyed and the labor of years annihilated. In 1794 he went out to the young States, whose cause he had advocated, to spend the last ten years of his life in the land of the future.

In 1800, when he confessed himself all but alone in his opinions, he published his last book, "The Doctrine of Phlogiston Established." In his last papers he replied to Noah Webster and Erasmus Darwin, attacking the theory of spontaneous generation and of evolution.

Priestley's eminent discoveries in chemistry were due to an extraordinary quickness and keenness of imagination combined with no mean logical ability and manipulative skill. But, owing mainly to lack of adequate training, he failed to apprehend to the full the true value of his great results. Carelessness and haste, not want of critical power, led him at the outset to follow the retrograde view of Stahl rather than the method of Boyle, Black, and Cavendish. Priestley is unjust to himself in attributing most of his discoveries to chance. His researches offer admirable examples of scientific induction. He has been called by Cuvier "a father of modern chemistry . . . who would never acknowledge his daughter."

Lavoisier upset the phlogiston theory of



ANTOINE LAURENT LAVOISIER
(1743–1794)

Stahl, according to which one and the same inflammable matter existed in all combustibles. He promulgated his theory of the admission of oxygen during combustion, and thereby began a new era in chemistry. He opened the way for the understanding of processes in the organic and inorganic worlds by his discovery of the law of the conservation of matter. He developed the discoveries of Black and Priestley, analyzed the atmospheric air, studied the process of respiration, of fermentation, and found that carbonic acid was a compound of oxygen and carbon. Based on Priestley's discovery, he showed the composition of acids, and demonstrated that the diamond really could be burned. With Cavendish he shares the honor to have demonstrated nitrogen and oxygen and the composition of water.

Antoine Laurent Lavoisier, born in Paris in the year 1743, received an excellent education. Very soon his interest in the study of natural sciences developed. As early as 1764 he distinguished himself through scientific investigations, when he won a prize offered by the

French Government for the solution of a difficult problem. The prize of 2,000 francs accorded to him alone he voluntered to share with his three competitors, in order to reimburse them for outlays they had had in experimenting.

This generous deed was rewarded by the King with a golden medal, given to him during the session of the Academy in 1766. In the year 1768 he was elected to membership of the Academy. All his attention he devoted to chemistry. Deciding to exert all his power to that end and at the same time to secure means needed for his experiments, he applied for the remunerative post of fermier general, and in 1776, as such, he was placed at the head of the powder department. Here he found opportunity to apply his exceptional talents to make scientific observations useful for technical purposes. As long as Lavoisier directed the fabrication of it, the French powder surpassed all others in quality. He was drawn to all commissions where for practical purposes a man of scientific knowledge was needed.

On April 18, 1787, Lavoisier presented, at a public session of the Royal Academy of Sciences, a memoir on the necessity of a reform of chemical nomenclature, which reform he wished to be considered as a national work. He reasoned as follows: Onomatology furnishes the real instruments for the operation of the mind; it is important that these instruments should be of the best kind, and it is indeed working in the interest of science—it is for the progress of science when we exert ourselves to improve our onomatology. Referring to the manner by which we acquire knowledge in general, he points out the importance of a perfect onomatology for those who begin to devote themselves to the study of science. The logic of science essentially adheres to scientific language. Science can not teach anything which is confessedly unscientific and false. In science we have to distinguish three things: the series of facts which constitute the science, the ideas which recall the facts, and the words to express the ideas. The word has to develop the idea, the idea has to embrace the fact;

these are three impressions with the same seal. Since the words preserve the ideas and transmit them, perfection in science is impossible without perfection in language. However true the facts may be, however correct the ideas developed by facts, only wrong impressions will be transmitted as long as the expressions by which they are communicated are not exact.

The reform of language effected by Lavoisier, in conjunction with Guyton de Morveau, Berthollet, and Fourcroy, was an indispensable prelude to the reform of thought. With the current alchemistic jargon, science, properly so called, could have no fellowship. By creating a scientific botanical nomenclature Linné has created scientific botany, and Lavoisier, by his scientific chemical nomenclature, scientific chemistry.

Bergman, the great scientist, the pupil of Linné, who died in the year 1784, wrote during the last days of his life to M. de Morveau, one of Lavoisier's cooperators: "Do not spare one single improper term." All Lavoisier's chemical works distinguish themselves by precision

of observation, masterly description of facts, and clear deduction of conclusions. Ingenious in the selection of requirements for his investigations, inventive in construction of new apparatus, persevering in all his researches, Lavoisier succeeded in demonstrating new arrangements of facts in chemistry and in establishing new truths of great importance to science. With productive originality Lavoisier united profound knowledge of all that had been accomplished already in chemistry. His influence on chemistry has been immeasurable.

All his merit as patriot, his fame as reformator of science, did not save him in the reign of terror, during which Robespierre had every man of true merit condemned to the guillotine, every one who was not insignificant enough to escape the suspicion of the tyrant. Upon a frivolous accusation that he had practised extortions while fermier general and had added water and injurious ingredients to tobacco while manager of the tobacco traffic, he was indicted in 1794. Indictment at that time meant sentenced to be guillotined. The courage of a

friend, who ventured to appear before the tribunal of terror and to enumerate the acomplishments of Lavoisier, was in vain, as an opposition to the brutality of those in power. This brutality is illustrated by the answer of the president of this tribunal: "Nous n'avons plus besoin des savants."

This man with the gigantic mind, whose great works in science will live for all time, was guillotined on May 8, 1794, out of revenge on the part of the people because he had held high positions under the king. Lavoisier was only fifty-one years of age when his life was taken on the scaffold in the name of the French Republic, the beautiful and glorious life of one of the greatest sons of France.

In 1823 Faraday succeeded in liquefying, and Thilorien in 1835 in solidifying, carbonic acid. Hey (1736–1819), Withering (1741–99), Percival (1740–1804), Dobson, Warren (1753–1815), Macbride (1726–78), Ingenhousz (1730–99), Beddoës (1760–1808), Henry, Lee, Rotheram, and White were the first to make systematic use of carbonic-acid gas for therapeutical purposes.

Percival, of Manchester, found that carbonic acid had antiputrid properties and observed also good effects from it in the treatment of advanced phthisis. He was aware, however, that in the treatment of phthisis it acted only as a palliative. He appears to have been the first, or at least one of the first, who conceived the idea of employing carbonic acid in cases of sordid ulcers. He reasoned: "Since the fixed air is able to modify the purulent surface in the lungs, it seems natural that it should be successful when applied externally on sordid ulcers." And this he found confirmed by experience. In cases of cancerous ulcer, in which the poultices of carrots had produced no effect, carbonic acid caused a disappearance of purulent matter, relieved pain, and gave a better aspect to the wound surface. The cases which he reported were treated in the Infirmary of Manchester, in the service of Dr. Withering. His observations were published in May, 1772. Two months later he wrote that the remedy had been applied during these two months, but without further result, and added: "It appears

that the course of the cancer is arrested by the employment of fixed air, but it is to be feared that not a single cure can be obtained by this means. Nevertheless, a palliative in such a frightful and hopeless disease should be considered as a precious acquisition."

Dobson, who likewise tried carbonic acid in case of cancer, came to the same conclusions. He could never report that the application of fixed air had produced a sensible effect toward cure, but found that the pain had successfully been combated. In non-malignant old ulcers of bad condition the gas produced excellent results. The pain was always relieved, the appearance of the wound markedly improved, and in some cases a complete cure ensued.

The analgesic and cicatricizing effects of fixed air were already well established when Beddoës learned, from the Dutch physician and chemist, John Ingenhousz, that carbonic acid had the remarkable property of quieting almost instantly even very severe pain, such, for instance, as is produced by vesication. The experiment of Ingenhousz was the following:

He produced a blister on the finger, removed the epidermis, and exposed the finger to the air; then placed it in a bell filled with oxygen and afterward in another bell filled with carbonic acid. The pain, which already had been lively while the finger was exposed to the air, became more intense in the oxygen bath, but disappeared quickly after the finger had been plunged into carbonic acid. This experiment was repeated several times by Beddoës, always with the same result. Macbride applied the gas to scorbutic ulcerations.

In the year 1794 Ewart published two cases of ulcerated cancer of the mamma treated with carbonic acid. The first of these was that of a woman, fifty-eight years of age. The ulcerated surface was situated on the upper part of the left breast and had an extension of from four to five inches. The ulcer emitted an offensive odor and had an ichorous, fetid discharge; the patient suffered severe and almost constant pain at the seat of the cancer. Already the next day after the application of carbonic acid the ulcerated surface had a better appearance and

the pain had entirely disappeared. There was no odor any more and the wound soon began to cicatrize. After two and a half months only a fistulous opening remained, and this also closed finally. Shortly after the publication of this case a report was spread and appeared in print that the patient had died. Contradicting this statement, Ingenhousz wrote to Beddoës, October 12, 1795, the following letter:

"On my return to Bath I saw the first patient, whose cancerous ulcer of the breast had healed, but had reopened again after carbonic-acid application had been discontinued. However, the ulcer has a less hideous appearance and pain is controlled by carbonic-acid applications. I believe it will heal again under renewed gas application, because there is always amelioration of the symptoms when gas is administered."

About ten months later, on August 26, 1796, Ewart himself wrote to Beddoës to inform him that the woman, the subject of the first observation, was still alive, but that the receded ulcer had not cicatrized as the primary one had

done, notwithstanding the constant application of carbonic acid. The only result obtained, and this was a permanent one, was the entire absence of pain and odor. There was no complete cure in this case, only temporary cicatrization.

As to the second case, which resembled the first very much and in which also carbonic-acid treatment had relieved pain and arrested the invading course of the ulcer, the patient died from intercurrent pulmonary disease.

Some years after the publication of Percival's observations and experiences (May, 1772), French physicians began to employ carbonic acid in the treatment of cancerous ulcers, and Ewart's two cases (1794) were much quoted. Follin claimed priority in introducing into France the gas as a therapeutic measure. He writes: "I have tried on some patients a new method of local anesthesia, which has never been practised in France before, and which consists in exposing ulcerated and painful surfaces to a continuous current of carbonic-acid gas." But such priority is not accorded to

him by Demarquay, who wrote that the method had been practised in France twenty-four years prior to Follin's claim.

The results obtained in England by Percival, Hey, Warren, and others were too important not to be considered by some French practitioners, and indeed everywhere in France experiments with carbonic acid were made to verify what had been learned from the experience of English physicians and what Priestley especially had popularized.

Carbonic-acid treatment became popular in France; it was foremost at the Academy of Sciences and Art of Dijon, where great scientific activity was developed and where facts were established showing the beneficial effect of the gas on all kind of ulcers and other affections. J. L. Targioni, of Florence, reported to this academy the details of a case of cancer of the mamma treated by fixed air. The gas had relieved the pain, corrected the bad character of the suppuration, and improved the general condition of the patient. About one-half the cancerous ulcer had become cicatrized.

In Paris there were also cases published by the Royal Society of Medicine, proving sufficiently the efficacy of the remedy. This society established a commission to investigate the subject; Lalouette was elected chairman. This commission confirmed that carbonic acid, altho it did not cure cancer, would relieve pain and act on open ulcers in a beneficial way by modifying the secretion and cause, to a certain extent, cicatrization.

In the year 1776 Abbé Magellan reported a case of very extensive ulcerating cancer, which under the influence of carbonic acid had become reduced to one-quarter of its former size. At a later period Demarquay, who has written the history of carbonic-acid treatment, reported from his practise analogous cases in which long-continued carbonic-acid-gas douches ameliorated the condition of cancerous ulcers, relieving pain and arresting the progress of the disease to such an extent that the patients gained in strength and courage, that their general health became comparatively very good; but all this was only temporary. He had also

cases in which the patients thus benefited and apparently on the way to perfect recovery died at an earlier or later period from an intercurrent disease. Cases of the latter kind were also reported in Demarquay's time from England. There appeared many publications on this subject in France, including one by Rozier, in 1776; Lalouette's report appeared in 1778.

Among the channels by which carbonic acid was introduced into the system was respiration. In former times carbonic-acid-gas inhalations of a specified degree were a well-known and extensively employed therapeutic measure. From the observation that the fumes of freshly plowed earth did good service to consumptives —as the belief was—the conclusion was arrived at that the carbonic acid of these fumes was the essential agent. Physicians went so far as to order patients to be covered with earth; they recommended them to stay in the cow-shed and even to sleep there. This treatment was widely accepted and became very popular.

In almost all European countries there exist

records, dating from the end of the eighteenth and the first quarter of the nineteenth century, according to which inhalations of air containing a high percentage of carbonic acid effected an improvement in, and sometimes the cure of, phthisis. Later on asthma was subjected to this mode of treatment. As recently as 1883 Edmond Weill spoke in the Academie des Sciences of Paris on his experience in applying carbonic-acid-gas inhalations to patients suffering from dyspnea. The sittings lasted from two to five minutes, once or twice daily, the inhalations being of pure carbonic-acid gas, the quantity being from 2 to 4 liters at each sitting. At no time were there experienced unpleasant symptoms, while the results were encouraging. Patients thus treated were consumptives and emphysematics. Coughing spells were relieved and prevented. It is not difficult to explain the effects thus obtained. The reports given leave no doubt that the relief secured was due to narcotic action, to a slight intoxication. The application of carbonic-acid gas in this form did not remain in practise very

long; the recognition of the merely symptomatic character of its curative effect on the one hand, and the risk associated with its employment on the other, caused it to be abandoned. Intravenous injections of carbonic-acid gas, which have been used repeatedly on animals, can not be taken into consideration and are not qualified to be enumerated as methodical application for therapeutic purposes.

In 1834 Mojon, of Genoa, published his experiences with the gas in gynecological practise, recommending carbonic-acid-gas douches in dysmenorrhea, a mode of treatment long before known but at that time forgotten. During the fifth decade of the nineteenth century Verneuil, Broca, and Demarquay in France, with Simpson in Scotland, made extensive use of carbonic acid in gynecological practise.

Brown-Séquard demonstrated the anesthetizing effect of the gas on the larynx. He showed that carbonic-acid gas applied to the mucous membrane of the larynx would induce anesthesia independently of its absorption by the blood. He experimented on ani-

mals inhaling fresh air through a tracheal opening, thus excluding symptoms of intoxication during experimentation. When both laryngeal nerves were intact, both sides of the body would become anesthetic after carbonic-acid gas had been insufflated for only a short time. When one nerve was severed, the opposite side of the body became anesthetic after carbonic-acid-gas inflation, but somewhat less so than it did when both nerves were intact. The anesthesia lasted only a short while and was followed by hyperesthesia. When both laryngeal nerves were severed, no anesthesia could be produced by carbonic-acid-gas insufflation.

For some time the gas was discredited in consequence of an event which took place in Scanzoni's clinic. A pregnant woman who had received vaginal douches of carbonic-acid gas died. Scanzoni attributed her death to the entrance of carbonic acid into the uterine cavity. The experiments of Claude Bernard and other French investigators brought conclusive evidence that Scanzoni was in error in attributing the cause of death in this case to the gas.

Breslau and Vogel published in 1858, in the *Wiener medicinische Wochenschrift*, a number of important experiments which they had made on pregnant rabbits. They inflated the vagina with carbonic-acid gas without producing thereby any toxic effect; no harm was done to the life of either rabbit or fetus. These investigators came to the conclusion that vaginal douches of the gas were entirely harmless in case of pregnancy, and that they endangered neither the life of the mother nor the life of the child. My own experience furnishes additional evidence.

Diruef, whose remarks are given in Demarquay's book, "Essai de pneumatologie médicale," Paris, 1866, as not having been published previously, says: "The baths of carbonic-acid gas which are given at different watering-places in Germany are known to have a very great effect in the treatment of such affections of the locomotor apparatus and the nervous system as resist ordinary therapeutic measures. Chronic rheumatism and gout, before the establishment of permanent anatomical changes, are affections

in which the application of carbonic-acid gas produces the most satisfactory results. There are even patients in this category whose skin does not support any kind of water-bathing, but only dry gas."

Rotureau ("Etudes sur les eaux de Nauheim," 1856) says: "The carbonic-acid-gas baths have been successfully employed, especially in rheumatic affections. The most severe of rheumatic affections is perhaps paralysis; the gas treatment has a most powerful effect on this manifestation of rheumatism. Of all forms of paralysis, paraplegia is the one quickest to vanish under this treatment and to attain the most complete cure. Paralytics who come to Nauheim, with the lower extremities more or less deprived of mobility, are subjected to the dry-gas treatment. Even when the paralysis is complete, the mobility returns gradually from day to day in a most remarkable manner, so that the effect of each bath can be noticed. There are cases in which the baths have been so effective that a rheumatic patient, who for whole years had not been able to use

his limbs, was enabled to walk after the fifteenth bath. One is surprised also to see what powerful effect the gas application has in cases of hysterical paralysis." This author wishes it distinctly understood that what he says of the effect of the baths of Nauheim has no reference to those forms of paralysis which are manifestations of organic disease of the brain.

Certain chronic neuralgias, such, for instance, as tic douloureux, sciatica, etc., have been successfully treated by means of the gas-bath and douche in cases in which numerous remedies had been tried for a long time previously and had failed. All observers are unanimous on this point, especially with regard to sciatica, excluding, however, those cases in which an advanced organic lesion is the cause.

According to the literature of the middle of the nineteenth century, gas douches are of service in oculopalpebral inflammation, but the treatment must be modified in the different forms of epipephycitis (barbarously called conjunctivitis)—namely, acute and chronic. In acute epipephycitis the douche is at first to be

directed upon the eyelids, because its direct application would cause pain and increase inflammation. The gas is to be applied until the eyelids redden; improvement is seen to follow even in the most acute stage. The action is prompt; photophobia, dacryorrhea, lagophthalmus, and the swelling of the eyelids disappear; these douches, therefore, offer, according to these reports, a valuable aid in the treatment of chronic epipephycitis. The gas-douche is also praised in the treatment of more profound inflammation—namely, in keratitis, even when ulceration has developed. It is said that in vascular, superficial, and even interstitial keratitis, relief follows generally after the first applications of the gas. Much more is found in the literature of our ancestors on the treatment of keratitis by means of the gas-douches, but this treatment has been abandoned, whether justly or unjustly is for ophthalmologists to decide. Unjust it is not to mention it any more in the text-books.

Demarquay speaks further enthusiastically on the treatment of amaurosis by means of car-

bonic-acid-gas douches, and says that their effect in this condition has excited the greatest attention. Mention is made also of the gas treatment in diseases of the ear, such as ulceration, and in certain forms of deafness.

Inquiry among many well-read specialists on eye, ear, nose, and throat diseases showed that they were not even aware of the fact that carbonic-acid gas had formerly been used as a remedy in a number of eye, ear, nose, and throat affections. Our later literature has omitted all mention of this even as an historical fact. It may further be stated that the gas has been employed in skin diseases.

A very gratifying and prompt effect is reported from the application of carbonic-acid gas in certain cases of cystitis and vesical neuralgia. Broca published his experience on this subject in the *Moniteur des Hôpitaux*, 1857, but I have been unable to see this journal. Demarquay, however, has published a large number of observations showing that carbonic acid is one of the best palliatives or adjuvants in such conditions. He relates the case of a

woman, thirty years of age, who suffered from neuralgia of the bladder without any known cause. The patient had frequent attacks, about twenty a day, lasting from five to ten minutes each time. Injection of carbonic-acid gas into the bladder practised twice a day brought about prompt relief. On the fourth day of this treatment the patient had only three attacks, and was completely cured after fifteen days' treatment. Before the gas douches had been resorted to, antineuralgics had been prescribed without avail. Demarquay speaks of the good results of the gas treatment in cystitis. In all cases, according to him, carbonic acid acts as a sedative—in a characteristic manner. At first it produces marked excitation of very short duration, which, while it lasts, seems to increase the symptoms of inflammation already existing. This may be due simply to its mechanical effect—that is, to its action as a foreign body, and also to its irritating effect on some mucous membranes, like that of the nose, at the first moment of application, particularly when the current of gas is very

strong. Afterward, especially on account of the facility with which it is absorbed by the mucous membrane of the bladder, it produces analgesia in this organ.

Demarquay gives a description of the different modes of application. As the best method he recommends that a rubber bladder, of the capacity of from thirty to forty centiliters, be filled with the gas, which is introduced from the rubber bag into the bladder by means of an ordinary catheter attached to the bag. Mondollot, in order to fill the bladder with carbonic-acid gas, employed a double-current catheter. If such an instrument is employed, care has to be taken that the gas may enter slowly, while the hypogastric region is closely observed in order to guard against excessive inflation. Such an accident may happen when one of the eyes of the catheter becomes obstructed by mucus; and, indeed, this accident did happen in Demarquay's own practise in a case of cystitis. The patient suddenly uttered a piercing cry and said that his bladder had burst, and such was found to be the case.

Such an accident can now be avoided, since we are enabled to measure exactly the amount of gas we wish to introduce and to regulate the current likewise with absolute certainty.

"If, instead of the carbonic-acid gas, atmospheric air had been injected," rays Demarquay, "I should have felt alarmed; but, knowing with what great facility the mucous and serous membranes absorb this gas, and knowing how harmless it is when brought in contact with the tissues, I felt almost reassured in regard to the consequences of this gas infiltration." In fact, tho the patient suffered some pain, probably caused by the rupture of the bladder, the gas became gradually absorbed, and after two hours it seemed to have disappeared completely.

Topical application of carbonic-acid gas in the shape of baths or douches has been tried quite extensively by balneologists of a former period, but a rational base for this kind of balneotherapy they have not given; in the literature of their time we fail to find specified rules based on exactly controlled observations. All

we can learn from them is that the gas exerts certain decided effects.

These effects are described as follows: When the patient is in the bath the pulse at first increases, but after half an hour's stay in the gas-bath this frequency becomes reduced. The gas produces a sensation of warmth to the skin, prickling and redness, especially at those parts which are most richly supplied with nerves—for instance, the scrotum; and in not a few patients perspiration follows. Micturition becomes increased in frequency and in the quantity of urine voided; there has been noticed an increased amount of urea in the urine. In women continued bathing has increased the amount of menstrual flow. The patient feels for hours after the bath cheerfully animated and freer in all his movements.

The physicians of Nauheim were the first to give a scientific description of the influence of carbonic-acid-water baths in different nosological conditions, especially in disorders of circulation. Beneke has demonstrated that the water-bath saturated with carbonic-acid gas is

a powerful and effective stimulant for the enfeebled heart. He was the first who had the courage to place dyspnoic patients suffering from uncompensated valvular disease in the bath. He also tried the effect of these baths in other morbid conditions, as in arthritis and nervous diseases. Schott and Groedl continued to work on this basis which had been laid down by Beneke. The brothers Schott have established a system of their own of physical therapeutics for disorders of the circulation, in which carbonic acid plays a rôle.

While this form of making use of the beneficial effects of carbonic-acid gas has become so popular with the medical profession, very little is known, or rather, as the foregoing historical sketch demonstrates, a great deal has been forgotten, about the external application of carbonic-acid gas in dry form.

The external application of dry carbonic-acid gas, considered in Franzensbad as an extraordinarily valuable therapeutical agent, is the product of the mineral springs there, which contain this gas in astonishingly large amount. At

different points it rises in the form of jets of dry gas. One of these springs—the so-called Polterbrunnen, renowned for centuries—surpasses in regard to the amount of contained gas all springs of this kind in the world. There the gas comes out of the ground with great force and a great deal of noise (whence the name Polterbrunnen). The gas is caught in a wooden receptacle and conducted from this vessel by means of a metallic pipe to the gas bath-house erected over the Polterbrunnen.

It is astonishing with how great force the gas is expelled constantly day and night in ever-equal volumes; this spring, Polterbrunnen, producing every minute 4 cubic feet, that is, in twenty-four hours 5,760 cubic feet, making 2,102,400 cubic feet of gas every year. Yet, immense as is this amount, it is only a small part of the immeasurable quantity which arises daily from the many thousand larger and smaller gas-springs of the extensive moor layer of Franzensbad.

In the bath-house over the Polterbrunnen there are common baths for a number of bath-

ers at one time, and also separate bath-tubs. The common baths are two wide, basin-shaped recesses with steps all around the walls, and benches to be occupied by the bathers. The single bathtubs are about one meter deep, also with benches of graduated height. In the bathtubs, as well as in the common bath-basins, the bathers *remain with their clothes on*, the gas at once penetrating the clothing and acting on the skin.

From the more recent history of the employment of the gas for medical purposes, we learn that Ziemssen, in the year 1883, published experiments to establish the value for diagnostic purposes of artificial inflation of the large intestine with carbonic-acid gas.

The introduction of carbonic-acid gas into the circulation by way of the rectum is an idea of recent date; at least, in older literature there are only a few notes here and there to suggest that this form of application had been thought of. The earliest recommendation of carbonic-acid-gas douche into the rectum I found in a materia medica published in the year 1863.

Bergeon, in the year 1886, published his new method of treatment of phthisis, based on the fact, established by Claude Bernard, that volatiles introduced into the rectum pass through the venous blood current to the lungs, where they will be eliminated without entering into the arterial system or developing any deleterious effect. Bergeon expected, by means of enemata of sulfureted hydrogen, diluted with carbonic-acid gas, to destroy the tubercle bacilli within the lung. His method became widely known and was extensively practised in France and in America. The great majority of those who had employed this method confirmed the observation that the general condition of the patients treated was improved; but they soon found that the tubercle bacilli did not disappear, and that all improvement of the general condition was due to carbonic acid and not to sulfureted hydrogen. This method was then completely abandoned, because it did not answer the main expectation; it did not cure tuberculosis.

Remarkable it is, however, and all observers

agree in this, that improvement of the symptoms is noticed in a wonderfully short time. Cornil and others explained this fact by saying that, if the improvement were due to destruction of the bacilli, one would suppose that the morbid symptoms would disappear only gradually.

Ephraim has treated patients with carbonic-acid-gas inflations of the rectum. Bergeon made use of this method in the treatment of whooping-cough. Demmé, of Philadelphia, has successfully employed the carbonic-acid-gas douche in a case of puerperal eclampsia.

CHAPTER III

INFLATION OF THE LARGE INTESTINE WITH CARBONIC-ACID GAS FOR DIAGNOSTIC PURPOSES

H. v. Ziemssen, in the year 1883, was the first to describe and publish experiments to establish the value for diagnostic purposes of artificial inflation of the large intestines. It may be admitted, however, that other investigators, those of the Berlin Medical Clinic, for instance, and other places, made experiments in the same direction, employing various methods, and were, as well as v. Ziemssen, aware of the significance of this diagnostic aid.

All that v. Ziemssen has said of the utility of carbonic-acid-gas inflation for diagnostic purposes may be said of inflation with air, pure and simple. His method is to develop the gas within the intestine, by introducing through a rectal tube, first bicarbonate of soda, then

water, and finally tartaric acid. Having the large intestine inflated, he found he was enabled to diagnosticate situs inversus viscerum, to demonstrate an acquired pathological position of the colon. He recommends this method for the purpose of ascertaining the relative position of the large intestine to a floating kidney and to ovarian and other abdominal tumors. By means of such inflation he discovered communication between the colon and stomach and between the small intestine and stomach. It also enabled him to study the relations of a fistula of the cecum, extending through the abdominal wall, and of a carcinomatous vesico-rectal fistula. Inflation was most of all serviceable in cases of stricture of the large intestine. In several such cases the exact location of the stricture could be ascertained, the surgeon being guided to the very point where to enter upon the gut.

V. Ziemssen used a solution of from 10 to 12 gm. of bicarbonate of soda and somewhat less tartaric acid to expand the large intestine. He found the method of inflation preferable to

that of pouring in water for the purpose of rendering passable stenoses and strictures of the colon.

He most emphatically advocates sudden expansion by means of carbonic acid to reduce abnormal positions, strangulations, intussusceptions, and twistings of the colon, as they are caused by perityphlitis, pericolitis, or periproctitis. Thus v. Ziemssen employed carbonic-acid gas as a mechanical agent.

Rosenbach has published a series of experiments made on the living, and also the results of experiments on the cadaver, by inflating the large intestine with liquefied carbonic acid. The selection of liquefied carbonic acid in place of the effervescent mixture offers a number of advantages: 1. It allows an exact dosage. 2. The introduction of the gas is absolutely uniform and constant. 3. The inflation may be interrupted at any desired moment and be continued again at will, so that much larger quantities of gas may be introduced. 4. There is no liquid applied together with the gas. 5. The pressure under which the gas enters is a

much higher one. 6. There is no apprehension of those accidents which are apt to happen when the two components for the development of the gas are introduced separately, which accidents may interfere with the success of the proceeding.

It must be conceded that inflation with air, as practised by Ewald, Runeberg, Oser, etc., by means of a rectal tube and spray apparatus, renders essentially the same good service; but carbonic-acid gas has been held preferable as being safer than the introduction of large quantities of unfiltered air.

The carbonic-acid gas is taken from an iron balloon, in which it is contained in the liquefied form; a double stop-cock is attached, to regulate exactly the flow of the gas from the balloon, in which it is naturally enough under high pressure. The carbonic acid, on escaping from the balloon, at once assumes the gaseous form. From the balloon it passes first into a bottle filled with water. This contrivance to have the gas pass through water is for the purpose of enabling us to observe and to control

the celerity of its escape. From this bottle it enters into an elastic tube terminating in a nozzle for the rectum. The nozzle having been inserted into the rectum, the stop-cock is opened to so limited an extent that we are enabled to count the gas-bubbles passing through the water.

In a few seconds after the gas enters the rectum there is produced a sensation of warmth in the anus, then a slight desire to stool is felt for a moment, but soon passes away. In patients who avoid pressure, control the levator, there is no voiding of gas, the muscular closure sufficing to retain it; in some cases it is advisable to secure closure by means of a rubber valve fastened to the rectal tube, which valve is pressed against the anal opening. If even this means should fail securely to close the opening, we may simply increase the amount of gas that enters by opening the stop-cock somewhat wider, when a satisfactory filling up of the intestine takes place. We soon notice now that the abdomen gradually becomes expanded, and when the patient begins to complain of ten-

sion we have to discontinue the introduction. It will be well to inflate the rectum empty in order to avoid obstruction of the tube by fecal masses. The presence of the latter, however, so long as they do not directly obstruct the lumen of the nozzle, is no hindrance; the gas passes alongside them while the intestine is stretching. The amount of the gas entering the intestine may be judged from the size and the number of bubbles which are seen in the water of the bottle spoken of, or may be calculated exactly by means of a manometer which can easily be inserted. For practical purposes, however, it is of no importance to know the exact amount.

Rosenbach has given a very thorough and exact description of the behavior of the intestinal tract when inflated with carbonic-acid gas, and his observations are of great value for diagnostic purposes; it does not, however, come within the scope of this treatise to enter into all the details of this useful investigation, since the results obtained are by no means characteristic of carbonic-acid-gas introduction, but may

be arrived at as well by inflation with atmospheric air. They are, notwithstanding, of great importance to us, in so far as they furnish conclusive evidence that carbonic-acid gas may be employed with perfect impunity.

Errors about carbonic-acid gas have been transmitted from book to book, from generation to generation. One of the grossest errors we find in the latest edition of Eulenburg's "Real-encyclopädie": "When carbonic acid has been introduced in large quantities into cavities of the body—as, for instance, the uterus—the intoxication produced thereby may become fatal by asphyxiation." A patient of mine, a lady suffering from dysmenorrhea, kept up introducing carbonic-acid gas into the vagina for hours at a time, because it gave her relief from pain. There was no asphyxia, and the idea of such a danger did not even enter my mind. When the inflation is carried out *ad maximum*, the lower part of the abdomen becomes expanded and the abdominal walls are under great tension, but, notwithstanding this, the liver is not at all or only very slightly pushed upward,

for on percussion over this organ the dulness remains about as before, there is no rising of the diaphragm, and consequently no retraction of the lungs, and no dyspnea is observed. All that may be noticed is a very slight acceleration of respiration and pulse, as will be mentioned presently. There is no cyanosis. The subjective symptoms of patients or persons experimented on are due to the disagreeable tension of the abdominal walls and the difficulty of expiration caused thereby, but even this unpleasantness disappears more and more as the patient becomes accustomed to inflation.

Rosenbach's experiments confirm the well-known fact that we can not, by way of the rectum, inflate the small intestine; especially conclusive in this respect are his experiments on the cadaver. The inflation can not be carried out beyond a certain limit, which limit corresponds exactly to that noticed in the living. In attempting to force introduction beyond this limit he did not succeed; the gas would escape through the anus or it would encounter such strong resistance that no more

could enter. He carefully opened the abdominal wall without injuring the intestine, and was then able to convince himself that, notwithstanding the considerable meteorism, the inflation did not extend beyond the ileocecal valve. The diaphragm was not pushed up nor was the liver displaced.

All experiments thus far have demonstrated that neither in the living nor in the cadaver can we force gas or liquid up through the ileocecal valve so long as the abdominal wall is intact; and even if the wall is opened the entrance into the lumen in question can only be forced when the injection is made in close proximity to the valve, so that from the anus, even while the abdominal wall is wide open, we can not at all, or only imperfectly, fill the ileum. From these facts we can be absolutely certain that the valve not only prevents regurgitation, but that there must exist other mechanical conditions causing the closure to be of great firmness. Among these factors are mentioned by Rosenbach, and by others before him, the physical and physiological behavior of

the abdominal muscles or the abdominal walls *in toto*, the action of the diaphragm which has a tendency to reduce the capacity of the abdominal cavity, the difference in the width of the lumina of ileum and colon on the opposite sides of the valve, as well as the muscular communication of the two intestinal segments, the axes of which are placed almost vertically to each other.

CHAPTER IV

THE THERAPEUTIC EFFECT OF CARBONIC-ACID GAS IN CHLORIASIS, ASTHMA, AND EMPHYSEMA OF THE LUNGS

Carbonic acid is absorbed by the mucous membranes, especially by the mucous membranes of the intestine, to a higher degree and with more facility than by the skin. The rapidity of this process may be judged from the shortness of time it takes for an artificial carbonic-acid meteorism to become reduced while there is no way for the gas to escape except through its channel of absorption.

The physiology and chemistry of respiration teach us that the carbonic acid of the blood exists as a constituent of combinations partly in the blood-corpuscles, partly in the plasma, and partly in the serum. Whether a change

in the composition of blood results where large masses of carbonic-acid gas have been introduced into the rectum, and from there have found their way into the veins, is not known, no investigations in this direction having been published. The amount of the chemically bound carbonic acid in the serum of the blood is proportional to the amount of carbonate of potassium therein, and similar relations exist likewise in the blood-corpuscles and in the plasma.

Therefore, whether any and how much carbonic acid may be absorbed in the blood remains as yet an open question. Symptoms of intoxication have never been noted. Röhrig has made experiments on rabbits in this direction. He found that very considerable masses of carbonic-acid gas might be introduced into the veins without producing symptoms of intoxication, tho such symptoms doubtless would occur if these masses had no opportunity to be eliminated by the lungs. Conclusive experiments on this point of venous injections were made by Nysten and Demarquay.

Nysten made a number of experiments which showed that carbonic-acid gas may be injected into the jugular vein and even into the carotid without causing serious accidents, provided the gas is introduced in small doses and slowly. If, however, the operation is performed too forcibly, if the gas is introduced into the blood too rapidly and in too large a quantity, death will ensue through distention of the cavities of the heart.

Against the experiments of injecting the gas into the jugularis, the objection has been made that the gas could not have time for action on the blood, because it would be transported at once to the lungs, whence it would be exhaled immediately. Demarquay, in repeating the experiments of Nysten and desiring that the gas should remain for a longer time in contact with the blood, selected the crural vein. The result corresponded exactly with the results formulated by Nysten. He injected into the cruralis of a good-sized dog, within forty minutes, 1 liter of carbonic acid, taking care not to inject more than from 5 to 6 centiliters

at the time. After the operation the animal did not appear sensibly affected. The next day after this experiment he injected into the same dog, again into the cruralis, another liter of the gas, but this time it was introduced within nine minutes, and 20 centiliters at a time. The animal made three or four inspirations and died. The necropsy was performed immediately. The cavities of the right heart were found to be very much distended. In beating slightly with the finger upon the right heart, a resistance was felt and a very well-pronounced elasticity. The aorta incised issued only blood at first, and then quite numerous bubbles escaped. The left heart was filled with rather spumous blood, a little less red than normal. The right heart was incised. With effervescence, a blackish foam spouted out, followed by very black blood. No clots were found in the heart. The vena cava was distended by the gas, which gushed out when pressure was made on this vein.

The lungs presented externally a reddish-slate coloration. On the periphery of the

right lung there was a good-sized ecchymosis. The surface of the kidneys was very brown.

In these two experiments Demarquay found, on auscultation of the heart, a very strong noise every time while forcing the gas into the vein; this noise was quite analogous to the dabble produced in a cavity of the phthisic. These experiments confirm those of Nysten, and speak in favor of the harmlessness of the gas.

Brown-Séquard, judging from facts of quite another character, thought he could demonstrate that carbonic-acid gas had decidedly a toxic effect. Continuing the experiments made by Bichat to this end, he studied the action of the blood charged with carbonic acid injected into the vessels, and he arrived at a conclusion which, in fact, is the best refutation which we could offer against his experiments. When we compare the phenomena of a complete asphyxia with those which present themselves after an injection of blood charged with carbonic-acid gas, we find that they are similar except that they are more violent in case of such transfusion when compared with those in

asphyxia. It appears that in both instances the phenomena under consideration depend certainly on poisoning by carbonic acid. The fact of the transfusion adds a new element to the question. It is not unlikely to cause the carbonic acid to penetrate into the blood in the form of a gaseous injection or by process of transfusion, and, since Brown-Séquard has stated that even in performing transfusion serious accidents will happen only when a certain quantity of blood is introduced rapidly, he admits, the phenomena apparently toxic which he has observed, are in a great measure to be attributed to the mode of operation.

The whole mass of gas introduced into the blood is carried to the lungs. From the lungs it is eliminated in a manner corresponding to the elimination of carbonic acid under normal conditions. The route which the carbonic acid pursues through the system is decided by the peculiarity of traveling in the direction in which it meets the least tension. On this law depends likewise its transmission from the tissues into the blood, as also its normal evapora-

tion from the blood into the alveoli of the lungs. Altho we know that this evaporation is limited, and is for one thing dependent on the celerity of the blood circulation, *i.e.*, upon the length of time during which the gas remains in the lungs, we may take for granted that at this point large masses are eliminated.

It is, therefore, evident that the carbonic-acid gas injected into the rectum and passing through the venous current causes no noticeable effect whatever in the system. Some of its therapeutic effects begin with its elimination from the lungs.

The acts of inspiration and expiration exert a direct influence on the contents of the upper air-passages, but not on the lower, especially not on the air in the alveoli, which latter is, to a certain degree, independent of the phases of respiration. The changes in this air required for the arterialization of the blood take place by diffusion. From the alveoli of the lungs carbonic acid finds its way toward the atmospheric air, and oxygen in the opposite direction enters into the alveoli. This ex-

change of gases is favored, as mentioned by Landois, by the so - called cardiopneumatic movement—that is, the shaking of the respiratory air with every contraction and every dilatation of the heart and every pulsation of the pulmonary arteries. Landois shows that on this cardiopneumatic movement depends the sustenance of life during hibernation and during catalepsy.

Ephraim interested himself and extensively tried rectal injections of carbonic-acid gas on patients. He reasoned as follows: The large amount of carbonic-acid gas introduced into the rectum passes through the veins, enters into the alveoli, and from there, obeying the physical law, is diffused in an upward direction, whereby an excess over the normal process of the diffusion of the gases takes place; that is, more than the normal amount of oxygen descends, the ventilation of the air-passages being thus increased. In making this assumption, that the alveoli with this increased afflux of carbonic acid receive an increased amount of oxygen, he had in view the law, according to

which gases interpenetrate other gases without causing pressure or expulsion—a law which in general governs the sustaining of respiration.

Experiments made by Speck have shown that increased ventilation of the lungs brought on by increased respiratory activity, that is, more profound inspirations, causes a large amount of oxygen to be retained in the body; but only a small part of this extra amount of oxygen enters the blood, by far the greater part of it entering into the composition of the residual air and enriching it in oxygen. With the increased activity of the respiratory organs the body uses up a larger amount of oxygen than normally, and the small extra amount in the residual air is needed to cover the deficit, whence there is not enough left to add noticeably to the oxygen of the blood.

Ephraim leaves the correctness of this explanation undisputed, but adds that no application of it can be made to the manner of increasing the oxygen under consideration, for, while the conditions bear some resemblance to one another, they differ in essential points.

He mentions the experiments of Pflüger on animals upon which tracheotomy had been performed as being more applicable. Here the conditions correspond with those presented by rectal inflation with carbonic-acid gas. Pflüger found that, with tracheal breathing continued for some length of time, the amount of oxygen would increase in the blood. This increase was due to facilitated and augmented lung ventilation taking place after tracheotomy had caused the shortening of the distance between the alveoli of the lungs and the atmospheric air, thereby facilitating the intrabronchial diffusion of gases.

The increased lung ventilation in animals with the trachea cut open corresponds with the better lung ventilation under consideration, to the extent that the oxygen in both instances is full gain, not being required for increased respiratory activity, but, according to Ephraim, the conditions for increased influx of oxygen into the blood are still more favorable when carbonic acid is introduced by way of rectal inflation than in the case of animals with open

trachea. Just as the rising of the extra amount of carbonic-acid gas through the veins causes an increased diffusion of gases within the respiratory passages, so will the gas diffusion between the blood and the alveolar air, which renders exchange of gases possible, be improved.

The result is not only an increase in the amount of oxygen contained in the alveoli, but also an augmented exchange of gases between it and the blood. The entrance of an extra amount of carbonic acid through the capillaries into the alveoli brings about increased diffusion, and a larger quantity of oxygen to the blood. The question whether this increased diffusion is followed by increased absorption, Ephraim thinks he can decidedly answer in the affirmative.

Summing up, Ephraim's view is that the carbonic-acid gas taken up by the digestive tract enters the venous system, is then eliminated by the lungs, and thereby brings on an improvement in the ventilation of the lungs, resulting in an increased accumulation of oxygen in the

blood, and that this is the main factor in the curative effects thus far observed.

Ephraim administered carbonic-acid gas by the rectum, the cases being exclusively those of outdoor patients, and he gave, as a rule, one, and in exceptional cases on account of special circumstances two, sittings daily. He employed the liquefied gas in the following manner: The carbonic-acid gas was taken from an iron balloon in which it was contained in the liquefied form; a double stop-cock was attached to regulate exactly the flow of the gas from the balloon in which it was, naturally enough, under high pressure. The carbonic acid, on escaping from the balloon, at once assumed the gaseous form. From the balloon it passed first into a bottle filled with water. This contrivance to have the gas pass through water was for the purpose of enabling us to observe and to control the celerity of its escape. From this bottle it entered into an elastic tube terminating in a nozzle for the rectum. The nozzle having been inserted into the rectum, the stop-cock was opened to so limited an extent

that he was enabled to count the gas-bubbles passing through the water. I have simplified

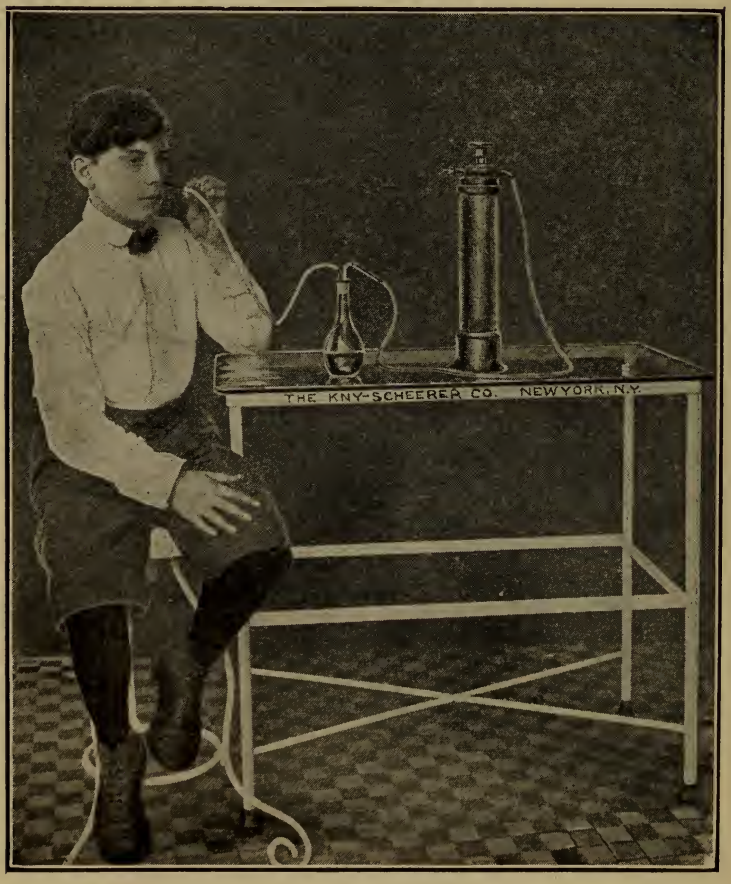


FIG. 1.—Small Cylinder for Liquefied Carbonic Acid. Mode of application to nasal cavity.

the apparatus he used, or rather reduced the size of the cylinder, so as to make it more convenient.

The patients treated by Ephraim were suffreing from chloriasis, phthisis, and asthma. There could have been no objection to more frequent application of the gas than one or two inflations per diem, but for his complicated and cumbersome method. These cases treated and described by him were as mentioned:

1. *Chloriasis* (incorrectly called chlorosis).—Eleven girls, varying in age from sixteen to twenty years. The circumstances surrounding them were most unfavorable in regard to health. All these patients belonged to the poorer classes. They were obliged to earn their living by working in factories. Their fare was consequently a very poor one. In order to secure the results of the carbonic-acid treatment pure and simple, nothing was altered in regard to their occupation and mode of living while under treatment. The cases selected were all of a severe form of chloriasis, and, except in one instance, were all of long standing and had been under treatment, some having been treated by Ephraim himself.

One of these cases was not benefited by the

carbonic-acid gas, in two cases there was marked improvement, and in seven a complete cure ensued. An examination of the blood was made in nine out of the eleven cases, but was confined to estimating the number of red blood-corpuscles. An unmistakable and in most instances a considerable increase in the number of red blood-corpuscles was noted, altho there was no examination made in regard to the amount of hemoglobin. Ephraim thinks that, judging from the improved general condition of the patients, there must have been an improvement in this direction. He admits that the improved condition of the patients may to some extent be due to the fact that the administration of gas regulated the stools.

Even with these favorable results before us, it would not be warrantable to speak of the introduction of carbonic-acid gas as an especially effective means for the treatment of chloriasis, but it may safely be said that it appears to be an excellent auxiliary in the treatment of this affection.

The result of the examinations of the blood

supports the theory of Ephraim that the healing effect is due to an increased introduction of oxygen into the blood. While I myself was treating a large number of children suffering from whooping-cough with carbonic-acid-gas inflation of the rectum, I observed that those who were anemic improved markedly in regard to this condition under the treatment.

2. *Asthma.*—There were treated altogether twenty cases, ten of which were suffering from true bronchial asthma, five from neurasthenic asthma, three from emphysema of the lungs, associated with bronchitis and asthma, the nature of which could not be exactly defined. All the ten cases suffering from bronchial asthma were relieved from these difficulties for a longer or shorter period of time. The result, which was a surprise, considering that the affection is, as a rule, intractable to all sorts of treatment, induced him to publish the cases in detail. None of the patients was given any medicine, nor was any change in the mode of living ordered.

I. Flora S——, 32 years of age, had suffered for seven or eight years from chronic bronchial asthma and slight shortness of breath. For one year she had attacks of dyspnea, which at first occurred in long intervals, but then became more frequent. During the previous four weeks she had an asthmatic attack lasting about half an hour every evening, which was accompanied with wheezing and blowing in the chest. During the night the patient slept little, and was obliged to sit up in bed.

Status præsens: Moderate emphysema of the lungs, diffuse and numerous rhonchi. In the sputum were a very large number of asthma crystals. The heart was normal. The patient could not go up more than one flight of stairs without resting. Treatment: Every afternoon she received one injection of carbonic-acid gas. After the second injection there were no more asthmatic attacks. After the fourth the patient slept through the whole night without waking, and at the same time the cough began to diminish. After the eighth injection there were no more asthma crystals found in the sputum. After the eleventh the cough was much diminished, rhonchi had disappeared, the patient climbed three flights of stairs without

resting, and the treatment was discontinued. During the next six weeks the patient remained free from attacks and from shortness of breath, but then the symptoms reappeared.

II. Josefa S——, 37 years of age, had suffered for a year from slight attacks of bronchial asthma, which lately made their appearance at intervals of from two to three days and lasted a few minutes. Percussion sound over the lungs was normal, and within normal boundaries there were numerous sibilant râles. In the sputum spirals and asthma crystals were in large numbers. After the first inflation came one more attack, but none afterward. At the same time cough and expectoration became less and râles were scarcer. The patient now climbs two flights of stairs in succession, while formerly she could not climb more than one without taking rest. The treatment was discontinued after the eleventh inflation. No further observation was made.

III. Clara E——, 21 years old, for nine years had suffered from cough, and occasionally appeared dyspnea. In the last few years the latter came on more frequently, and during the last two years almost every night. After August 10, 1889, the attacks were very severe

and lasted from one to two hours. During the day there were slight shortness of breath, cough, and abundant expectoration.

Status præsens: Here we had well-pronounced emphysema of the lungs, diffuse sibilant râles, in the sputum numerous spirals, and a very large number of asthma crystals. Treatment with carbonic-acid gas begun on August 15. During the following seventeen days, one injection being given daily, the attacks appeared in undiminished frequency, but their severity was lessened soon after the commencement of treatment. This was noticed by the patient as well as by the mother. The amelioration made progress continually, so that after the seventeenth inflation there were no more attacks; the cough was, however, only little improved, and the râles could still be noticed. On the whole, twenty-eight inflations were made and the patient was dismissed. Iodide of potassium with apomorphin was ordered. During the treatment the patient gained remarkably, probably because her sleep was so much better, that is, undisturbed. After fourteen days the catarrhal symptoms became less. During the following three months the patient remained entirely free from attacks, but subse-

quently from time to time a slight difficulty in breathing appeared, which has repeated itself often since the middle of April, 1890.

From this time on occurred from eight to ten attacks weekly; they were, however, milder than the former ones. On May 2, 1890, the carbonic-acid treatment was resumed. The result was about the same as before. The attacks assumed, even after the first inflation, the character of a passing oppression, and disappeared entirely after the nineteenth inflation. After seven more inflations had been given, the treatment was discontinued. Catarrh as well as shortness of breath were much improved. Climbing of stairs was much more easily done than formerly. Five months after the discontinuance of the treatment the attacks had not returned.

IV. John P——, 66 years old, for two years had asthmatic attacks, appearing only during the night and lasting from one to two hours; during a few months they appeared every night, and during the day there was shortness of breath. Very slight emphysema of lungs and few râles were observed. With the beginning of the carbonic-acid treatment the attacks became shorter and lighter, and with the seven-

teenth inflation ceased entirely. During the following days, once in a while there was a little oppression, "as if I entered a smoky room," said the patient. After the twenty-second inflation even these ceased. After treatment the patient slept regularly the whole night through. At the same time his continual shortness of breath was remarkably relieved. After having received the thirty-second inflation the patient was dismissed, being in an essentially better condition. During the next three months he remained free from attacks, but then they began again, tho in a mild form and at long intervals.

V. E. H——, 62 years old, had a barrel-shaped thorax, considerable emphysema of lungs, and chronic bronchitis. He had had a severe asthmatic attack every evening for from five to six months. After the second inflation the attacks ceased; under continued treatment the catarrh improved considerably; patient slept all night long without, as was formerly the case, being disturbed by coughing. He was dismissed after having been given the seventeenth inflation. Four weeks later the patient presented symptoms of insufficiency of the heart, under which he died after a few days.

In the mean time he had had no recurrence of the attacks.

VI. Elizabeth P——, 25 years old, had pronounced sclerosis. She had often suffered from cough; the least exertion, climbing of stairs, etc., brought on dypsnea. For five weeks bronchial catarrh and severe asthmatic attacks occurred every night. These latter ceased after the fifth inflation, and the patient slept every night uninterruptedly until morning from this time on. Eventually the catarrh disappeared. The patient was dismissed after having had the thirteenth inflation; the bronchi were entirely free. One year later the attacks had not returned.

VII. Clara W——, 14 years of age, had suffered since her eighth year from attacks of difficulty of breathing, which at first appeared at intervals of several months, but for a few years had appeared at intervals of from three to four weeks; they lasted from two to three days, and ended with abundant expectoration. The patient came under treatment fourteen days after such an attack. She received twenty-five inflations. During this treatment patient had still, once in a while, a slight oppression with cough, but no real attack. Six weeks after-

ward came a mild attack lasting three hours. Again seven inflations of carbonic-acid gas were made. During this renewed treatment slight oppressions reappeared from time to time, when treatment was again discontinued. From this time on patient had no attack during seven months and a half, when again a spell of the former intensity and of two days' duration occurred.

VIII. Anna W——, 22 years old, had suffered for one year every night from light and short attacks of difficult breathing. After the second inflation they ceased. The patient had received only four inflations when for external reasons she did not present herself any more for treatment.

IX. Bianca J——, 23 years old, had suffered for one and a quarter years from difficulty of breathing, which made itself noticeable during fast walking and climbing of stairs, and was more marked in the evening. For the previous twelve days every evening an asthmatic attack came on, lasting one or more hours. There was slight emphysema. Auscultation, except during attack, revealed nothing abnormal. After the second inflation there were no more attacks; with the seventh inflation treatment was

discontinued. There were, however, symptoms of a dry bronchitis, but eight weeks later no new attack had appeared.

X. Mrs. A——, 50 years old, for four years had been subject to asthmatic attacks, which afterward came on more and more frequently. During four weeks there had been daily attacks of from three to four hours' duration, occurring mostly during the night, seldom during the day.

Status præsens: Emphysema pulmonum with numerous sibilant râles. In the sputum were many spirals and crystals. During the first four days of carbonic-acid treatment there was little change, but after the fifth day the attacks disappeared. After two more inflations the patient declared herself cured, and stayed away from treatment. The cough had decidedly improved, râles were considerably reduced, and the patient remained perfectly free from attacks during the following eight weeks; then they reappeared, but less frequently and in lighter form.

In the cases enumerated the effect of the carbonic acid was noticeable after various lengths of time; the chances of cure were better the shorter the time the evil under treat-

ment had existed. But even in the chronic cases subjective and objective improvement was noticeable almost from the commencement of treatment; that is, improvement in regard to either duration or severity or both. Amelioration of the shortness of breath was noted, not only during the attacks, but during the intervals; and bodily exertions, such as climbing of stairs, could be executed with greater facility. Simultaneously with the relief of dyspnea and asthmatic difficulty there was experienced a most beneficial influence on the bronchial catarrh. Only in one case (No. III.) was no change noticed during treatment, and in another case the improvement took place after treatment had been discontinued.

In all other cases the cough improved, the râles became less or disappeared completely. Especially noteworthy are three cases of emphysema of the lungs, which Ephraim treated with carbonic-acid gas. The history of all three is essentially the same. There were considerable emphysema, chronic bronchial catarrh, cough, and shortness of breath, which,

naturally enough, increased under bodily exertion. In all three cases relief was secured after a comparatively small number of inflations (seven, nine, and eleven respectively), the dyspnea improved considerably, the catarrhal symptoms disappeared completely in two cases, and in one almost completely. The volume of the lungs, however, underwent no alteration.

Résumé: The results of the carbonic-acid-gas treatment of asthma are shown in improvement of shortness of breathing and of the bronchial asthmatic attacks, which improvement sometimes lasts for a certain period, while at others it is permanent.

It is to be mentioned again that in all these cases only a limited number of inflations were given. Ephraim observed in some cases that nightly attacks would be prevented when inflations were made during the afternoon, but would come on when the inflations were given during the forenoon.

My own experience in treating asthma by means of carbonic-acid-gas inflation of the rec-

tum confirms fully all that Ephraim has observed. My patients—outdoor patients of the dispensary—made the inflations themselves by means of my simple gas generator (see Fig. 2). Being enabled to apply the gas at any

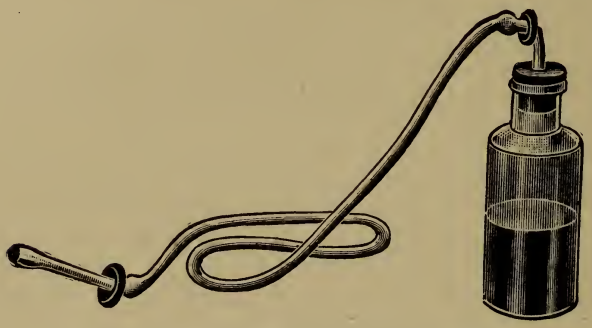


FIG. 2.—Rose's Carbonic-Acid-Gas Generator.

time, they secured, without exception, as far as I know from reports they gave, freedom from attacks during the night; they enjoyed, sooner or later, complete rest at night, and all were relieved from bronchitis. Two cases I had under observation for about two years, and saw lasting benefit in regard to bronchitis and asthma. Both patients made use of the gas with more or less interruptions—according to their statement—for many months.

CHAPTER V

CARBONIC-ACID GAS IN THE TREATMENT OF DYSENTERY AND MEMBRANOUS ENTERITIS AND COLIC

Carbonic-acid gas, besides stimulating capillary circulation, has an anesthetizing influence, and this is especially remarkable when the gas is applied to painful ulcers—cancerous, for instance; and it was well made use of in gynecologic practise. There exists a large literature of the first half of the nineteenth century on this subject. On account of these two qualities, the stimulating and the anesthetizing, it is indeed an ideal remedy in old ulcers —irritable as well as indolent ulcers. As an antiseptic it is of limited value. When antiseptic principles were first established in the treatment of wounds, all wound remedies were tried as to their germicidal powers. In regard to carbonic acid, we know now that certain bac-

teria can live and thrive in it almost as well as in atmospheric air, that others develop imperfectly or slowly, and that a third class grows in it only when the cultures are exposed to breeding temperature. Saprophytes, altho they do not thrive in it, do not perish in carbonic acid. It does not affect the bacillus of typhoid fever, but it destroys the bacteria of anthrax and cholera. It interested me very much to learn from Dr. Alice Byram Condict, of Bombay, India, one of the matriculates of the New York Post-Graduate Medical School, while I was lecturing on carbonic acid before the class, that the physicians in India—the home of the cholera—insist strictly that people should drink no water except that charged with carbonic acid.

In an old book, which is perhaps rarely consulted any more, Sobernheim's "Arzneimittellehre"—the last edition appeared in 1863—I found that Kuester and Perkin had treated ulcers of the rectum, especially in cases of dysentery, by inflation of the rectum with carbonic-acid gas. In no other books or papers on materia medica published since 1863—and

I have consulted all I could find in the New York Academy of Medicine and the Surgeon-General's Library of Washington—have I seen this method mentioned. Theoretic reasoning and a reading of this recommendation of Kuester and Perkin made me apply the gas in dysentery. The first case thus treated by me was published in *The Annals of Anatomy and Surgery*, December, 1883, and, as it appears to me a specially instructive one, I may be permitted to give it in full as it was published in the said journal.

Mary R——, 19½ years of age, born in Ireland, been four months in America; a domestic; fairly developed; and had been enjoying tolerably good health. She began to menstruate at seventeen years of age. Her menses appeared every two, sometimes every three, weeks, lasting from four to six days, and were painful at the beginning. On September 2, 1883, she was taken sick with fever and diarrhea characterized by tenesmus. Was vomiting. The day following the stools contained matter and blood. I saw her first on September 5, and poured into the rectum both large and

small quantities of warm water at varying intervals, while the patient occupied a recumbent position. I did this, as I had often found it successful in relieving tenesmus. None of the drugs employed, such as calomel cum opio, oleum ricini cum opio, tannin, bismuth, and plumbum aceticum, had any marked or lasting effect. The patient remained feverish and suffered greatly almost every night from frequent tenesmus, discharging blood and pus, sometimes with fecal matter resembling masses of blue clay. The little relief she obtained was more from ice or iced cloths to the abdomen than from any of the other means employed.

On September 19 Dr. Alfred Bessard anesthetized the patient, and I proceeded to make a thorough examination of the rectum in the way described by Dr. J. Gaillard Thomas. The mucous membrane, as far as it presented itself to view, was swollen, of a dark red color, and studded with deep ulcers, thickly covered with pus. After having cleansed the rectum with water from a Davidson's syringe, I wrapped a piece of wet cotton around the end of a rod, having dipped the cotton in pure nitric acid, and lightly touched the swollen mucous mem-

branes and all the ulcers in the manner practised by Dr. Thomas. The first night after this procedure the patient slept well, did not suffer from tenesmus, and felt better in every way; but the night following she was, as she and her friends expressed themselves, "as bad as ever." I then ordered suppositories of iodoform; they brought only temporary relief, and the same was the case with injections of chloral.

Almost from the commencement of her sickness the patient had been coughing. Physical examination showed slight dulness on percussion on the right side, below the axilla, between the third and fifth ribs, and, corresponding with this area, there were crackling sounds on inspiration. The patient being very much reduced by constant fever, restlessness, and pain, and presenting this probably metastatic affection of the lung, her case appeared indeed a desperate one.

In the forenoon of September 27 I inflated the rectum with carbonic-acid gas, and this one application, which caused no discomfort or tenesmus, was at once followed by a change for the better. There was no fever on that evening and very little tenesmus during the night;

she slept well and improved, so to say, from hour to hour in every way. There were some matter and blood discharged, but only during the night following the first application; the next morning she had a natural evacuation from the bowels without either matter or blood, *and never again discharged either.* Tenesmus ceased gradually during the following nights. There was no more straining after October 1. For nearly five days the bowels moved as often as five or six times daily, very little at a time, the stools being in the shape of small, hard balls; and as long as this was the case, I had the carbonic-acid douche applied three times a day. The patient described the effect of such applications as being that of an agreeable sensation, and she asked for it. During the days immediately after the first inflation tenderness and irritability of the stomach existed, which disappeared promptly after the patient had taken a few powders composed of ten grains each of subcarbonate of bismuth and bicarbonate of soda. The condition of the stomach having been corrected, the appetite improved rapidly. After October 2 the patient was able to be out of bed all day. The bowels after October 4 moved regularly and naturally once a day.

There were still slight dulness on percussion on the right side and diminished breathing, but no more crackling sounds, and the cough almost ceased.

During the last twenty-two years I have inflated the rectum with carbonic acid in all cases of dysentery which have come under my treatment, and invariably have noticed the prompt effect on the tenesmus. As a rule, patients have spoken with enthusiasm of the relief they obtained. Dr. R. E. Van Giesen, of Brooklyn, has informed me that he also knows the remedy, that he has made it a practise to inflate the rectum with carbonic-acid gas in cases of dysentery, and that his results have been most gratifying. In simple dysentery we may, by means of this topical application, dispense with administering medicine per os. Experience with this treatment in amebic dysentery I have none. I should judge, however, that altho it might not destroy the ameba, it would be of service at least in alleviating the distressing tenesmus.

In July, 1900, I addressed a letter to the

Surgeon-General of the United States Army, Washington, suggesting carbonic-acid-gas treatment of dysentery among our soldiers in the Philippines, among whom the death-rate from this disease was exceedingly high at that time. In my letter I stated the experience I had had and the theoretic reasons which prompted me to call attention to the method. I received the following reply:

"WAR DEPARTMENT,
"SURGEON-GENERAL'S OFFICE,
"Washington, July 18, 1900.

"*Dr. A. Rose, 126 East Twenty-ninth Street,*
"*New York City, N. Y.*

"SIR: I have to acknowledge receipt of your communication of the 16th inst., with enclosures, calling attention to your discovery of a new method of using carbonic-acid gas in the treatment of dysentery, and to state that the matter will receive due consideration. Very respectfully,

"O. B——,
"Assistant Surgeon-General, U. S. A.,
"Acting Surgeon-General."

Since the receipt of this letter I have not heard any more from the Surgeon-General's

Office in regard to carbonic-acid gas. I do not wish to find fault with the War Department, except for branding the method as a new discovery of mine. Nothing can be further from my intention than such a claim. It is to be supposed that the War Department was overwhelmed with new discoveries and looked upon them with suspicion. It is simply a revival of an old therapeutic measure, which has, as the facts presented show, unjustly been forgotten.

The physiological effect of carbonic-acid-gas inflation of the rectum suggests itself as a most rational remedy in cases of enteritis membranacea and colica mucosa. Both Dr. Robert C. Kemp and myself have seen prompt relief from colic as well as from discharges of mucous strips in cases of several years' standing. There is one case of Dr. Kemp, published in "International Clinic," vol. iii., 13th series (1903), which is in so far valuable as the patient had been under observation during five years. This case is that of a woman of thirty-five years, who had been passing mucus from the bowels with the characteristic pains for

seven years. During the last five years she had been under observation. Here existed a complication of hyperchlorhydria and gastroptosia. I saw the patient on December 20, 1902. The treatment consisted in abdominal strapping, Illoway's hyperchlorhydria diet, and inflation of the rectum with carbonic-acid gas. She improved from day to day. From January 2 to January 9, 1903, the day she was dismissed, she had passed no more mucous strips.

My own case, in which the effect of carbonic-acid-gas inflation of the rectum could be demonstrated, was that of a lady of thirty-five years, who had been suffering for years from colica mucosa, for the relief of which morphin injection had been resorted to daily for two years. As much as sixteen grains of morphin had sometimes been administered on one single day. She had not been without morphin for more than twelve hours any day. On February 6, 1900, I began with inflation of the rectum with carbonic-acid gas. Since the administration of the gas—and no other treatment was given—the morphin injection was discon-

tinued; patient found instant and permanent relief from the mucous colic and no desire for morphin any more. This lady had been attended for many years by many physicians. I will not enter into the details of this case, but confine myself to the fact that carbonic-acid-gas inflation of the rectum brought prompt and permanent relief from mucous colic.

CHAPTER VI

CARBONIC-ACID GAS IN THE TREATMENT OF WHOOPING-COUGH

Since the year 1887 Bergeon has been using carbonic-acid gas in whooping-cough. He inflates the rectum with it immediately after the attack, provided three hours have elapsed since the last meal. The child is allowed to eat at once after the inflation, as the digestion is not interfered with. If a fresh coughing spell sets in, the inflation is to be repeated as soon as four hours have elapsed since the one previously made. In very obstinate cases he inflates also during the night. According to Bergeon, even the severest forms require only a week of treatment. Bergeon has published and spoken in medical societies on this subject, but has failed to make converts. One day it happened, at a dinner party of medical men, that he was sitting next to Professor Girod,

who had been suffering for three months from whooping-cough and had tried in vain a number of remedies. Bergeon interested Girod in his method. Girod tried it with excellent result on himself and his children, who were at the same time similarly afflicted.

I forget when and where I first read of the employment of carbonic-acid-gas inflation in whooping-cough, but I have been employing this method of treatment since May, 1894, and have had an opportunity to order it in quite a number of cases among my patients of St. Luke's Society of Grace Parish. In all but a few cases the reports I have received have been that the application of the gas has had an unmistakably good effect. Relief was observed in the first few days, and the patients were often cured entirely within from eight days to two weeks. As a rule the children coughed less frequently after the first application, and after four or five days' treatment they ceased coughing during the night, while in the day they would cough only after they had been running or had taken similar exercise. I attended

a family in which the mother had two children suffering from pertussis while they sojourned at a fashionable seashore hotel. In the family, also, the mother's sister, who remained in New York and had only occasionally visited her sister and the children at the seashore, became affected and was subjected to the carbonic-acid treatment as soon as I had made the diagnosis. In all these cases the result was most gratifying. I do not lay down rules, as Bergeon does, as to the frequency and the time of application. I only direct that the inflation be made at least two or three times a day. I have found that the result is better and more prompt the oftener the inflations. In two out of about forty cases of children treated for St. Luke's Association, the mothers had reported that there was no improvement. It is noteworthy that in both these cases the treatment with carbonic acid was successful in children of the same families.

The following well-observed cases of pertussis treated by carbonic-acid inflation furnish conclusive evidence of the efficacy of this method of treatment in some instances:

Mr. D——, a lawyer, had a wife and four children. He occupied four rooms on a second floor. His children were: Emily, aged seven years; Helen, aged five years and nine months; Agnes, aged four years; and Philip, aged two years. The three little girls slept in one room, which was well ventilated; the window was kept open all day long, even during cold weather. The three little girls were taken sick with whooping-cough, while the youngest, the little boy, remained free from this disease.

Helen D——, who goes to school, began to cough and to sneeze on November 11 and grew worse daily. It was not until the 17th that she remained at home from school. I was summoned to see her on November 18. On the 17th she had had nine convulsive attacks during the day and twelve during the night from the 17th to the 18th of November. The face had the characteristic edematous swelling. On November 18 the carbonic-acid-gas inflations of the rectum were done three times. The attacks on that day were much milder in character and only four in number; there were also only four mild coughing spells during the night from the 18th to the 19th. In this case

there was no epistaxis. The coughing spells assumed a milder and milder character under the carbonic-acid treatment until November 28, when the inflations were discontinued. During the days from November 28 to December 4, while no gas was given, the spells became more violent and were more frequent again, until they were equal in both respects to those which had been observed shortly before the gas was applied. Gas inflations were begun again on December 5, and were continued up to December 8. Again a most remarkable beneficial effect was noticed, gradual amelioration of the character of the attacks, and lessened frequency. From December 8 to December 9 the child coughed only twice. During the night from December 10 to December 11 there was no cough at all. During the day, December 11, she coughed three or four times, but very slightly.

Emily D——, 7 years old, had slight cough and sneezing from November 18 to November 25. She stayed at home from school on the 25th, and had the inflations made from that day until December 4, like her sister, three times a day. The convulsive attacks were severer in this case and brought on epis-

taxis; the frequency, however, was less. She coughed four times during the day and six times during the night before the gas was administered. The first day on which the gas was given she coughed only once during the night and twice during the day. There was edema of the face also in this case. During the days on which the gas was not used the attacks reappeared with their former severity, but assumed at once a lighter character and were less frequent under renewed treatment. No more gas was administered on December 10. There was no cough at all on December 11.

Agnes D——, 4 years old, began to cough simultaneously with Emily—*i.e.*, on November 18. Treatment with carbonic acid was begun on November 25. In this case the convulsive attacks were the severest, the most violent, the edematous swelling of the face more marked than in the two other cases. After the application of the gas the attacks were reduced in number from twelve to six during the day and from nine to four during the night. Epistaxis ceased after the first day's treatment with gas. While the cough was less frequent, it was also less violent. This child was of a much more

nervous disposition than either Emily or Helen.

Philip, the little boy, had only a light cough without any symptoms characteristic of pertussis. No treatment was given.

During the time of treatment the weather had been most unfavorable, so much so that the children had to remain in the house all the time; even as late as December 13 none of them had been outdoors.

In all these cases the appetite improved with the improvement of the symptoms of the affection.

After December 10 no more gas was applied. All the children were then doing well; they coughed once or twice a day, but only slightly.

In the spring of 1897 Dr. Joseph O'Dwyer gave the carbonic-acid treatment for whooping-cough a trial in the New York Foundling Asylum. The result was published by Dr. Joseph O'Dwyer and Dr. Reed D. Norton in their treatise on whooping-cough, which appeared in the fourteenth volume of the "Twentieth Century Practise." During 1897 at this

asylum one hundred and fifty cases of pertussis were treated by carbonic-acid inflation. Of the whole number, one hundred and forty-three showed very marked benefit. The vomiting ceased even in the severest cases by the second or third day, the whoop disappeared, and the number of paroxysms was reduced to two or three daily. The seven remaining cases were apparently not benefited, one of the seven being well advanced in the disease before this treatment was instituted. The duration of the disease, so far as could be determined, was not influenced. Not the slightest ill effect of the treatment was observed. During the administration of the gas the faces flushed decidedly, and this effect lasted some fifteen minutes. The gas was given to the children three times daily, some two or three hours after meals. In infants the treatment lasted five minutes each time; in the "runabouts," ten minutes.

During the following year I treated a large number of children afflicted with whooping-cough in the New York Foundling Asylum, but I have to confess that there could not be

noted any effect either on the duration or on the severity of the disease in the cases treated by me. I had not witnessed the mode of application under Dr. Dwyer's direction—I was absent from the city during the time—but I learned that the patients had been turned on their faces while the gas was administered. This fact accounts for the flushing of the face, of which the report speaks.

On the whole I have found that, while the carbonic-acid-gas inflation of the rectum will be of most marked benefit in some cases, it will have no effect in others.

Dr. N. R. Norton reported two series of cases of whooping-cough occurring in two different years treated by rectal injections of carbonic-acid gas. Out of one hundred and fifty patients, one hundred and forty-three were benefited to a very noticeable extent. After the injections vomiting ceased and the paroxysms of coughing were less frequent and less severe. The seven cases that were not benefited were of weakling children in advanced stages of the disease. The carbonic acid was obtained from

a mixture of bicarbonate of soda and crystals of tartaric acid. By this method the gas is given off sufficiently slowly, so that its administration may be kept up continuously for the necessary length of time. In infants the injections were given for five minutes at a time; in older children for ten minutes. The administration of the carbonic-acid gas was followed by flushing of the skin, especially of the face. In a few of the patients mild diarrhea developed. This seemed to be produced by the irritation of the rectal tube. It ceased after a day or two, when the injections were discontinued, and they could usually be resumed a day or two later without necessarily causing the diarrhea. As children suffering from whooping-cough frequently have diarrhea, it is doubtful whether the carbonic acid or the method of administering it was the cause of the frequency of stools.

CHAPTER VII

CARBONIC-ACID GAS IN IMPOTENCE AND IN SOME GYNECOLOGICAL AFFECTIONS

As we have seen, the first noticeable effect of carbonic-acid baths is a peculiar sensation of warmth and reddening of the skin. This effect is most marked on the inner surface of the thighs, the perineum, the scrotum, the labia, and on all parts which are especially well supplied with sensory nerves. As a rule, there is an increased desire to micturate, and afterward the amount of urine voided is unusually large. The physiological effect, therefore, consists of congestion in the vascular system and irritation of the peripheral nerve-ends.

It has already been mentioned that carbonic-acid baths have been recommended in affections of the nervous system in general, as, for instance, hypochondria, hysteria, neuralgia, per-

ipheral paralyses, and, in combination with gymnastics, in disorders of circulation. The rational application of carbonic-acid-gas baths or douches can be of service in the treatment of some forms of impotence and in many gynecological affections.

Investigations have proved that the effect of carbonic-acid-water baths does not essentially differ from that of carbonic-acid-gas baths. The blood pressure is increased as well by the dry carbonic-acid-gas bath as by the carbonic-acid-water bath. In some cases, moreover, as much or more service may be rendered by the simple gas douche of carbonic-acid gas as with either water or gas bath.

Physicians in watering-places are aware that men who are easily excited are apt to have erections during their stay in the carbonic-acid-water bath, and that in many the libido becomes markedly stronger under treatment by such baths. It is the peripheral irritation near the sexual organs which increases sexual sensation. This effect may be noted when the rectum is inflated with carbonic-acid gas, evidently due to

the innervation, discovered by Fellner, of the rectum by branches of the nervi erigentes.

It is self-evident that those forms of impotence which depend on malformation, congenital defects, diseases like diabetes, nephritis, cerebral lues, tabes and other spinal diseases, and atrophy of the testicles are not amenable to treatment by carbonic-acid gas. Carbonic-acid gas may, however, be of service in neurasthenia sexualis, in nervous impotence caused by diminished utilization of the capability of the spinal center, or by disorders of their reflex conduits. It is a remedy also in cases which present a reduction of activity of the cerebral center of erethism in general, in forms in which we intend to create an excitement by means of peripheral irritation.

In cases of spermatorrhea, pollutiones diurnæ, ejaculatio præcox, in which the nervous weakness depends on morbid irritability of the spinal apparatus for ejaculation, carbonic-acid gas is not to be resorted to; in such cases hydrotherapeutics and electricity are more suitable measures, because our object here must be

to reduce the irritability and to improve the power of resistance. It may, however, happen that after the last-named remedies have done their work, carbonic acid will be indicated. An exceptionally favorable field presents itself in impotentia senilis præcox.

In the female conditions of oppression, of atonia, or of torpor of the sexual organs, relief may be afforded by means of carbonic-acid-gas douche, and sterility depending on anaphrodisia may be cured.

Continued use of the gas-baths may produce metrorrhagia or even menstruation in cases of amenorrhea. Fellner observed menstruation occurring in isolated cases after a single gas-bath.

It has been said that modern gynecology did not pay sufficient attention to the influence of the nervous system on diseases of women—that the effect of uterine diseases on the nervous system was made almost exclusively the subject of observation. We know of uterine dyspepsia, that is, gastric trouble brought on by uterine affections, and we can explain this reflex

relation of the two organs, since both are supplied with sympathetic fibers. The same is the case with uterine cough, a reflex symptom manifested in the organs of respiration. We know that the symptoms will disappear as soon as the corresponding uterine affections have been relieved. Most important are manifestations of sexual disorders in the nerve-center or the peripheral nervous system, neuralgias and neuroses dependent on uterine disease. In these cases the pathogenesis of the reflex symptoms is easily explained, on account of the abundant innervation of the generative organs and their connection with the sympathetic through the plexus hypogastricus and also with the spinal nerves through the internal pudic nerves. These neuralgias are of frequent occurrence. Intercostal neuralgia is a common complaint, so much so that Bassereau said that there was almost always a metritis at the bottom of it. Facial neuralgia, infrequently lumboabdominal neuralgia with extension into the ramus femorocutaneus, mostly on the left side, may likewise be connected with uterine trouble.

Simpson and Scanzoni mention in this direction also neuralgia of the serratus and coccygodynia. Some cases of tachycardia may belong in this chapter, and, finally, all disorders of the nervous system collected under the name of hysterics.

In regard to the relation of the nervous system to gynecological affections, the following is to be considered: There can be no doubt that, as a rule, a much stronger irritation is required to excite sexual desire in woman than in man, and to bring on during coitus that orgasm with the sensation of ejaculation which gives the feeling of satisfaction. If this satisfaction is wanting, there will develop in the course of time a nervous condition which in some instances culminates into an invincible aversion to the approaches of the husband. Many physicians may be able to illustrate this painful example in this chapter. This aversion, sometimes associated with colpospasmus (barbarously called vaginismus), amenorrhea, and other anomalies of menstruation, many hysterical symptoms, reduction in flesh or the gain-

ing of too much, are some of the manifestations of its nervous influence. When we have to deal with such conditions and find on gynecological examination no evident pathological condition, then carbonic-acid-gas applications are highly to be recommended in order to improve the sexual sensation in woman, to aid menstruation, and to exert a beneficial influence on sexual neuralgias and neuroses.

Piéry, of Lyons, succeeded, in six out of seven cases of vaginal blennorrhea associated with colpospasmus, in obtaining complete relief by the application of carbonic-acid gas in a nascent form. This mode of treatment is correct in principle, but unnecessarily complicated in execution. Seven parts of bicarbonate of soda and six parts of tartaric acid rolled up in a piece of gauze are to be placed in the vagina, when the development of the gas takes place under the influence of the vaginal secretion.

In all cases of colpospasmus in recently married women which came under my treatment, I succeeded in giving relief by means of carbonic-acid-gas douches in the vagina.

There can be no doubt that carbonic-acid-gas baths or douches are effective in certain forms of menstrual disorders, as, for instance, dysmenorrhea, oligomenorrhea, and amenorrhea; also in cases of so-called frigidity and sterility depending on such frigidity. They may serve in case of chronic metritis with erosion at the vaginal portion. The direct effect of carbonic acid on the uterus is manifested by intenser reddening of the portio vaginalis and marked increase of secretion. After repeated application of the gas douche, the menses will appear in some cases somewhat earlier and in most instances more copious than is customary. In the systematic application of the gas douche we possess a very effective emmenagogue, which will prove beneficial in the cases mentioned. First of all, those cases will be amenable to this treatment in which there exists no anatomical change of the sexual organs and in which the ailment can be traced to disturbance of innervation or disorders of metabolism. The good results of carbonic-acid treatment in oligomenorrhea or amenorrhea of fat women are

well known. But even in cases of endometritis with oligomenorrhea or amenorrhea, carbonic-acid douches may accomplish a cure after other methods of treatment have failed, and in such cases—that is, after other methods have been tried in vain—we should never omit to give carbonic-acid-gas douches a trial.

An ingenious apparatus, devised by Mr. Thomas Warker of New York, for the purpose of imitating the douche of the Krähnchen spring at Ems, is described in the *Medical Record*, December 18, 1875. The spring in question, as well as one of similar composition at Plombières, in the east of France, has long been noted for the value of its waters in the treatment of sterility and chronic uterine diseases. The mode of application of these waters at Ems is quite primitive, and consists simply of a bathtub, with a perforated bottom, through which the douche is conducted by means of a pipe. The patient sits in a straddling position, when the douche finds its way into the vagina. The spring itself, being somewhat higher than the bath in question, supplies

the force to the vaginal jet by means of hydrostatic pressure. Mr. Warker, in his apparatus, has very successfully fulfilled all the conditions necessary to insure the desired results of a lo-

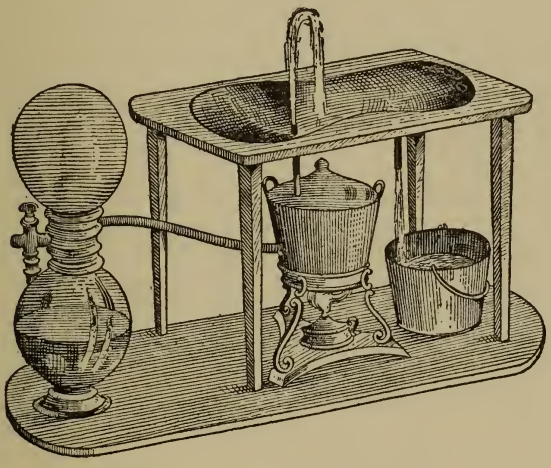


FIG. 3.—Warker's Ems Spring.

cal application of water of the Ems spring. This water itself is made artificially and is contained in a glass fountain charged with carbonic-acid gas. To this receiver (as will be seen in the cut) a pipe is connected which passes through a water-bath and thence to the bath above, across which the patient sits. The amount and force of the jet is regulated by a valve in the receiver, while the alcohol lamp

underneath the water-bath raises the temperature to the desired degree. The surplus water escapes in a vessel provided for the purpose. The extremity of the jet-pipe is supplied with different kinds of nozzles to suit the different requirements of the volume and character of the stream.

Theodore A. Demmé, of Philadelphia, describes a case of puerperal eclampsia in which the rigid and unyielding os dilated under the influence of the carbonic-acid-gas douche, and other cases in which such douches relieved painful labor and seemed to aid the dilatation of the os. The following is his report, published in *The Medical and Surgical Reporter*, Philadelphia, February 18, 1871, entitled "On the Induction of Local Anesthesia in Labor by the Use of Carbonic-acid Gas":

CASE I.—In December of last year I received an urgent call to wait upon a lady who, it was stated, was in labor and had been in convulsions for several hours. Upon arriving at the house I was informed by the midwife having the patient in charge that she had been in

labor over twenty hours; the bag of waters had ruptured almost at the commencement of labor, and, altho the pains were frequent and excessively severe, the mouth of the womb had scarcely dilated any during the last ten hours, and that she was about to request the attendance of a physician when convulsions came on. I recognized at a glance that I had before me a terrible case of eclampsia or puerperal convulsions. The patient was lying in a totally unconscious condition, and at short intervals would be seized by a spasm, convulsing every muscle of the body, jerking violently the head to one side, and at the same time bending the body backward as if the head and heels were to approach one another; the features were distorted, the throat and face tumid and purple, and the eyes rolled up in the orbits—it semed as if they would start from their sockets. Upon examination I found the os uteri dilated to about the size of a half-dollar piece, and extremely hard and rigid. This rigidity continued not only during the pain, but in the intervals; there was, in fact, a constant spasmodic rigidity. The commencement of a pain and the onset of a convulsion were almost simultaneous, it appearing as if the pressure of the

child's head upon the irritable and sensitive os was the direct cause of the eclampsia.

The indication was undoubtedly to dilate the os and deliver, but every attempt at forcible dilatation aggravated the symptoms, and I therefore bled the patient freely from the arm, in the hope of promoting the relaxation of the spasmodically contracted muscles; but, altho I controlled the arterial circulation and reduced the volume and frequency of the pulse, I found that even excessive bloodletting had no effect upon the rigid os. The idea then flashed upon my mind of using the carbonic-acid gas. After a delay of fifteen minutes consumed in procuring the apparatus, I applied the gas to the uterus. When the douche had been continued for about five minutes, it was evident that some change had been produced, for the patient remained quiet and no convulsive movement took place. A few minutes more, and the anxious family, startled by the great change that had occurred in the behavior of the patient, imagined that she was dying, and only the regular beating of the pulse assured me that such was not the case. Fifteen minutes after the application of the gas there was a slight tremor of the body, when I again carried the gas-tube into the va-

gina, and in so doing examined the womb, and to my astonishment and great satisfaction found the os not only no longer rigid but fully dilated, and the head about passing the superior strait. I immediately applied the forceps and delivered. The patient, after remaining unconscious for several hours, suddenly awoke as if from a sleep, and asked for a glass of water. Convalescence proceeded favorably.

In this case we had a revelation of the power of carbonic-acid gas as an anesthetic agent over an extremely sensitive and irritable os uteri, controlling rigidity without any apparent interference with the contractile or expulsive efforts of the uterus.

Case II.—January 3, 1871, Mrs. D——, primipara. When called to the patient, labor had been in progress about two hours. The pains were excessively severe and frequent. The patient was nervous and extremely irritable, allowing neither herself nor those surrounding her any rest. Per vaginam examination gave little hope of speedy termination. The os uteri was dilated about one-half, the edges

dry, hot-and-cold-like. After waiting thirty minutes and perceiving little or no progress, I determined to use the carbonic-acid douche. The patient, having been assured that she would receive relief, offered no opposition to the application. After the gas had been allowed to act upon the mucous membranes for five minutes, the entire demeanor of the patient was changed. The demonstrations of suffering, impatience, and irritability were succeeded by a calm so complete that it seemed as if the labor had been suddenly arrested. The douche was repeated in ten minutes, and the observation made that, while the patient asserted that she felt no pain, the bag of waters was pressing firmly upon the now rapidly yielding os. In exactly fifteen minutes from the termination of the first douche, the dilatation being almost complete, I ruptured the bag of waters and almost immediately perceived the head entering the pelvis. Five minutes after the escape of the waters the third application of the gas was made. The head had now entered the pelvic cavity and was pressing upon the perineum. The patient at this time, in answer to the questions, stated "that she felt no pain," "did not feel the head at all." In fact, did not believe

she was to have a child. Very shortly after, however, the relief from suffering ceased and the passage of the inferior strait was accomplished with all the usual symptoms of pain. The further progress of the case presented no particular features.

CASE III.—January 4, 1871, Mrs. D——, aged 37; second confinement, thirteen years elapsing since the birth of the first child. When engaged to attend this lady I anticipated a difficult labor, in consequence of the great length of time that had passed since the birth of the first child. Such was, however, not the case. Being called to the patient at 9 A.M., I was enabled to leave the house at 11:15 A.M., the mother lying comfortably in bed and the nurse dressing the new-born babe.

In this case I made four applications of the gas, at ten-minute intervals, during the first (or dilating) stage of the labor, with the effect of greatly ameliorating but not entirely relieving the sufferings, the patient complaining from the very commencement of labor of pain in the back and of cramps in the limbs.

Case IV.—January 21, 1871; Mrs. E——, primipara. The gas douche applied every ten minutes, with the effect of relieving the pain in so marked a manner that it was with difficulty that I could convince the mother and nurse that I had not stopped the labor. Indeed, it was only when the sufferings became intensified, as the head pressed on the perineum, that they again had faith. In this case the gas injection was applied four times, at intervals of ten minutes.

Dr. Demmé, in conclusion, says: "I would urge upon my medical brethren to give this agent a fair trial, and to report their experience. The number of cases in which I have used the gas is too limited to form a proper estimate of its value. Nevertheless, in cases of rigid, unyielding, irritable os uteri, I regard it as a boon, relieving the suffering and expediting the labor."

The paper of Demmé in which these cases are given has been referred to in several of my publications on carbonic-acid treatment. I mentioned Demmé's discovery before the Obstetrical Section of the New York Academy of

Medicine, on the occasion when I reported a case of my own in which I had succeeded in producing anesthesia during labor by means of the carbonic-acid-gas douche; but it seems, indeed, that a method discovered by an American physician has to be discovered by, or at least ascribed to, some European physician before the profession here will take the pains to notice it or give it a trial.

As far as my knowledge goes, Demmé was the first who wrote on this method of anesthesia in labor, and I have not seen a single notice in any journal of his paper; certain it is that it is not mentioned in any of the text-books on obstetrics that I have examined.

When we ask why this apparently very valuable aid to suffering women has not been generally adopted in midwifery, we can find no other answer than that it was a certain fear which even Demmé helped to create when he said: "There are certain precautions to be observed in applying this agent. It must be remembered that one of the most powerful sedatives is being experimentally tried, and the

condition of the mother must be carefully watched. The pulse and respiration should be frequently examined, and particular care given to furnish a free supply of air to the respiratory organs. The head of the patient somewhat elevated upon pillows, etc." Fortunately all these anxieties are superfluous since we have studied the physiological action of the carbonic-acid-gas douche on the system.

But there exists another fear in regard to the application of the carbonic-acid-gas douche, which has perhaps prevented its more general adoption in gynecological practise, but which fear is without foundation. This error has been spoken of already in the chapter on the history of carbonic-acid-gas treatment. I will shortly recapitulate: Scanzoni, in the year 1857, recommended the carbonic-acid-gas douche as a means of inducing premature birth. This recommendation, forming the title of a paper of Scanzoni, has been quoted since then without any commentary in all the writings on the therapeutic application of carbonic-acid gas. Whoever takes pains to peruse Scanzoni's arti-

cle will become convinced that carbonic-acid gas is perhaps the most unsuitable and ineffective means ever tried for the purpose in question. Scanzoni had the erroneous idea, and insisted upon it, that the carbonic-acid-gas douche to the uterus would cause contractions of that organ. Even the demonstration of the prominent gynecologists, Simpson, Hohl, Guitar, and Carl Braun, to the contrary did not move him. Gustav Braun tried to bring on premature delivery in a case of deformed pelvis. For this purpose he directed the carbonic-acid-gas douche to the uterus and had such applications continued daily for thirteen days in succession. We may judge what an immense amount of gas he injected during these thirteen days, when we learn that it took forty ounces of concentrated hydrochloric acid and a corresponding amount of marble to develop the gas for injection. A Woulfe's bottle was used. Finally, a colpeurynter had to be placed into the vagina, the patient had to be brought into a sitz-bath, and, in addition to all this, was severely injured by accident with the hydro-

chloric acid. Gangrene of the labia, the vagina, and the cervix uteri was the consequence, and the patient finally died from peritonitis. Gustav Braun complains to Scanzoni that the procedure was too expensive, whereupon Scanzoni replies that he had successfully attained the end in twenty sittings and that only one florin and fifty kreutzer (about sixty cents) were spent by him for chalk and hydrochloric acid in such a case.

Carl Braun tried to induce premature delivery by means of carbonic-acid-gas douches in one case. He had ten sittings, each of half an hour's duration, but, as the case required quick action, he finally introduced an oiled elastic catheter into the uterine cavity. His opinion was that this gas douche was much more unreliable than the plain water douche and the colpeurynter and the introduction of the elastic catheter into the uterine cavity, and that it was the most expensive method, which alone would interfere with its being generally adopted. Hohl says that carbonic-acid gas introduced into the vagina would be as little apt to cause contractions of the uterus as if it were applied to

the abdominal wall. All this demonstration of plain and indisputable facts only excited Scanzoni to violent polemics. Scanzoni himself is dead, but his error haunts us yet.

Early in the year 1884 I was called to a neighboring city as consulting physician in a case of incessant vomiting in pregnancy. All the usual remedies had been employed in vain. I for the first time suggested the introduction of carbonic-acid gas into the vagina, and exhibited my simple apparatus. My idea was to make use of the anesthetizing effect of the gas on the womb, especially on the os. I assumed that the vomiting in this case might be a reflex action; originating in neurosis of the uterus. My suggestion was not accepted. It happened that my colleague had in mind the title of Scanzoni's paper above mentioned, and feared contractions of the uterus and abortion.

A well-known German gynecologist, Adrian Schücking, arrived at the same conclusions as myself in 1885. It is possible that the curative effect of carbonic-acid gas in vomitus gravidarum has been known before Schücking and myself

made use of it, but no reference of this kind is found in Schücking's paper, nor have I found it mentioned in literature. He published in the *Centralblatt für Gynäkologie* an article, entitled "Zur Therapie des Vomitus gravidarum," in which he describes a case of incessant vomiting of pregnancy and in which, other measures having failed, he irrigated the rectum with the carbonated water from the Pyrmont Spring. This water is highly charged with the gas. After the first application of this water vomiting ceased. In the same paper he recounts a case of incessant vomiting in a girl with an ovarian tumor, in which, as in the preceding one, the vomiting was controlled by irrigation of the rectum with carbonic-acid water.

I have confined myself to inflation of the rectum with gas and have never applied the gaseous water in cases of vomiting of pregnancy. The results have been invariably gratifying. I have not met with another case of so-called incessant vomiting. Perhaps by applying the carbonic acid early graver symptoms have been prevented in one other case I attended.

CHAPTER VIII

ON THE EFFECTS OF CARBONIC-ACID BATHS ON THE CIRCULATION

On taking a bath, the temperature of which is below that of the skin, there will be a sensation of cold, regardless of whether such bath is taken in the river, the sea, the ordinary bath-tub, or in the shape of a water-bath charged with carbonic acid. This cold sensation, however, will soon disappear, as the human body adapts itself to all environments. In the case of flowing water, the motion is converted into heat, so that water in motion appears to be warmer to the body.

If a test-tube is filled with water in which bicarbonate of soda is dissolved together with an acid, the thermometer will rise, heat being liberated, as is always the case in chemical reaction. If the person, while taking the bath,

observes a quiet attitude, an infinite amount of heat stimulations will continuously affect the same spot, to which stimulations that spot will answer—as it will to any other continuous stimulations—by dilatation of the vessels.

In regarding the process from this standpoint, there is no fundamental difference between massage and carbonic-acid baths. The latter, however, have the advantage that by means of a very simple method the entire body may be subjected to massage at one and the same time, an effect which can not be attained either by hand massage or even by apparatus. Besides, this massage of the entire body has the advantage of extreme uniformity. The effect of the bath in flowing water is increased, because here motion is converted into heat.

According to Homberger, of whose paper—"Ueber die Wirkung der kohlensauren Bäder"; Vortrag gehalten auf dem Balneologen-Congress, 1905, *Berl. klin. Wochenschr.*, 1905, No. 22—I avail myself to almost its full extent, the effect of gaseous baths is not produced by the gas, whether this is carbonic-acid gas, oxygen

gas, or air, but, to use a general term, by the transmutation of phases, heat in *statu nascendi.* This opinion is not in accordance with the results of recent investigations concerning the effect of carbonic-acid baths. Leopold Fellner, who, like Homberger, read a paper ("Zur physiologischen Wirkung der Kohlensäure") at the twenty-sixth public meeting of the Balneological Society in Berlin, March 9–13, 1905, and of whose paper I avail myself as I did avail myself of Homberger's, says: The resorption theory which was at first generally recognized was denied by some, but now is supported again by the investigations of Hugo Winternitz, who adduced proof of the resorption of carbonic-acid gas by the increase of the same in the atmosphere without increasing the consumption of oxygen. There has also been some controversy as to the nature of the irritation which carbonic acid exercises upon the skin. The opinion was entertained that carbonic acid exercised a chemical irritation upon the cutaneous sensory nerves; later on some investigators drew the conclusion from their researches that

the irritation exercised by carbonic acid was of a thermic nature.

They were led to this conclusion by the following facts. An average thermic point of indifference is lowered or raised in proportion to the heat-conducting and heat-producing capacity. For atmospheric air the point of indifference at medium moisture lies between 20° and 25° C. The heat-producing capacity of carbonic acid is less than that of the atmosphere, the proportion, according to Regnault, being 0.20246 to 0.2374; and the heat-conducting capacity is still much smaller than that of the air, namely, 59 to 100, according to Warburg. Therefore, the point of indifference of carbonic acid must be considerably lower than that of the atmospheric air. For water the point of indifference is at 34.5°, and reaches up to 36.4° C. A water-bath at 28° C. is cool for the majority of normal people, while moist air at 26° C. is so warm that it can not be borne for a long period. Therefore in a carbonic-acid bath the first effect of the water is a sensation of cold. Then the carbonic-acid

bubbles, which become separated from the water and also become heated beyond the point of indifference, produce a thermic irritation, and the consequence is that not only a frequent change between cold and warm sensations takes place, but there are numerous changes of cold and warm sensations simultaneously. There are pronounced effects of contrast such as are not possessed by any balneotherapeutic or hydrotherapeutic agent singly.

This would clearly explain the thermic effect of carbonic-acid baths, and it is intelligible that, in spite of the colder temperature of a carbonic-acid current, the skin experiences a sensation of heat, because the circumambient air has a higher point of indifference. On the other hand, there are a number of manifestations in connection with the use of carbonic acid which are not explained by the thermic effect alone.

Carbonic acid has both a stimulating and weakening effect upon the sensory and motor nerves. It stimulates the circulation and respiration centers (Ludwig, Hoffa, Brown-Sé-

quard), and reduces the cardiac function in the diastole (vagus irritation, Cyon). It increases susceptibility to touch, as has been proved by Kisch, but reduces it after prolonged action (more than three-quarters of an hour). It creates a finer sensation of space, as was proved by Basch and Dietl. It has an anesthetizing effect (Brown-Séquard). It acts upon the sexual organs.

On the other hand, by irritating the sensory fibers of the skin, it produces reflex changes of respiration and circulation. This was explained by Hugo Winternitz, when he observed that a carbonic-acid bath had the effect of increasing the volume of respiration to such an extent that the direct irritation of the resorbed quantity of carbonic acid upon the respiration center could not be considered a sufficient explanation, and that the presence of an additional reflex irritation had to be assumed in order to explain the increase in volume. As regards the change in circulation, we observe in the process of vasodilatation a reflex action produced by the nerve-centers of the vessels.

All these manifestations point to the fact that carbonic acid produces not only a thermic, but also a chemical, effect.

Thomas E. Satterthwaite, in his book "Diseases of the Heart and Aorta," gives the following concise and clear description of the effects of carbonic-acid baths: Carbonic acid is absorbed by the skin and has a reflex action on the vasomotor centers, followed by dilatation of the arteries and capillaries, and this dilatation is manifested by a sensation of warmth and redness of the skin. The pneumogastric is affected, for the frequency of the pulse is lessened. The inspirations become deeper. Dilatation of the vessels permits them to be better filled, and this means acceleration of the blood current, as we shall see presently. Diminution in cardiac frequency favors diastole, so that the ventricles are better filled, and, while they discharge more blood, they take up more blood and relieve venous congestion. In this way there is a tendency to restore the balance of circulation between the arterial and venous systems.

Homberger rightly opposes the largely prevailing opinion that functional work is taken off the internal organs when there is abundant flow of blood to the skin. It has been proved by Bier and Klapp that hyperemia produced by heated skin spreads to the lower strata, and from this it follows that dilatation of the skin vessels is not necessarily followed by a contraction of the visceral vessels.

The temperature of all organs is dependent upon the quantity of blood passing a given place during a unit of time. As vessels contract, there is a decrease in the generation of heat. It has been assumed that an increased blood supply in any sphere of the body would be followed by a diminution in another sphere. In reality, however, the quantity of blood is constantly changing, and the regulation of the same takes place in the capillaries.

The effect of carbonic-acid baths had been supposed to assert itself upon patients with heart diseases somewhat in this way, that, after dilatation of the skin vessels, those of the internal organs would contract and thereby lessen

the demands upon the cardiac function. This is, as we have seen, not the case. The visceral vessels are dilated in exactly the same way as the skin vessels, and physiological observations have shown that, as vessels become dilated, the blood flows more rapidly.

When a part of the body is placed in hot water or in a hot-air apparatus, the venous blood turns light red and even pulsates. The volume of the part increases, illustrating the effects of a permanent bath, as can be proved plethysmographically. Therefore, the blood circulates more rapidly when the vessels are dilated. On irritation of the nervi erigentes, the vessels become dilated, and consequently the blood circulation is accelerated. An irritation acting upon the human body causes a congestion, and under the microscope the dilatation of the vessels can be observed, as well as the acceleration of the circulation. Physiology does not furnish a single instance in which the speed of the circulation decreases with simultaneous dilatation of the vessels. In our vascular system there are two forces, the pressure

and the suction force, supporting each other. The heart is not a mere pressure-pump, as was taught by Harvey and as has been the teaching for centuries; it is also a suction-pump. The interdependence of the pressure and suction forces is subject to changes; under certain conditions they may balance each other, so that the motion of the arterial blood is effected by pressure, that of the venous blood by suction, and that of the capillaries by both pressure and suction.

The suction or siphon action not only plays an important rôle in the cardiac function, but everywhere else in the body where vascular dilatation creates a vacuum, the power of the siphon action causes an acceleration in the flow of blood as the vessels become dilated.

Carbonic-acid baths and blood pressure have been two inseparable conceptions during the last few years, and are of great importance in the treatment of cardiac and vascular affections.

In arteriosclerosis the blood pressure is often increased, a manifestation which in this affec-

tion is not considered a favorable symptom. Carbonic-acid baths increase the blood pressure, in spite of which, however, they exercise an improving influence. The explanation is as follows:

Increased blood pressure may be caused in two different ways, pathologically and physiologically. The former occurs by increased resistance in the vascular system, the latter by accelerated circulation. The former adds to, and the latter detracts from, the amount of work to be performed by cardiac function. The favorable effect of carbonic-acid baths in the case of patients suffering from heart diseases is explained on the ground of accelerated circulation, which reduces the demands made upon the cardiac function. In contradistinction to this phenomenon, augmented blood pressure by increased resistance always means additional work for the heart. Therefore the increased blood pressure in arteriosclerosis is pathologic, but by the action of carbonic-acid baths the pathologic process may be changed into a physiological process.

This physiological explanation of the effect of the gas in arteriosclerosis given by Homberger I found practically confirmed in a case of far-advanced sclerotic degeneration, especially of the valves of the heart. Here the beneficial influence of the gas baths was especially manifested by preventing and relieving the attacks of angina pectoris from which the patient had been suffering frequently, especially during the night. Indeed, while this patient was under my care during many months of his stay in this city, his life was made very comfortable compared with the state in which he had been, relying on nitroglycerin and amyl nitrite. Many a peaceful night was secured by means of the carbonic-acid-gas bath.

In the year 1890, Dr. J. Jacob reported at the Congress for Internal Medicine, in Vienna, the results of his experiments to determine the specific effect of carbonic acid, externally applied, on blood pressure; and again in the *Zeitschrift für klinische Medizin*, Bd. XLIX., he published the result of his publication. His experiments were conducted in a most exact

and scientific manner, but it is difficult to understand why he went to work with unnecessary complications. The simplest way would have been to give the person experimented on a dry carbonic-acid-gas bath. Instead of that, he gave, first, plain-water baths at an indifferent temperature of 36° or 35° C., and afterward carbonic-acid-water baths of the same temperature, in order, as he says, to study the effect of carbonic acid, when externally applied, on blood pressure.

He took great precautions to avoid errors, gave the water and the carbonated-water baths alternately, and changed the order at different times on different days. He found that the after-effects of both forms of bathing consisted in enlargement of the volume of the heart pulse and acceleration of blood circulation of the aorta, but that these effects were produced in a higher degree—greater acceleration of blood circulation in general, stronger diastole, as well as stronger systole of the heart—after the carbonated bath than after the simple water bath.

It was to me a matter of interest to investigate how by the mere effect of carbonic-acid gas all these physiological processes take place which are always referred to in examining the effect of carbonic-acid-mineral baths—the frequency of pulsation, respiration, and blood pressure.

We have learned in the historical chapter that while the carbonic-acid-water bath as it is given in Nauheim and artificially prepared everywhere is very popular with the medical profession, very little is known, or rather a great deal has been forgotten, about the external application of carbonic-acid gas in dry form.

As far as known, Franzensbad is the only place now where natural carbonic-acid gas baths are administered. Fellner, in a paper read at a meeting of the Balneological Society in Berlin, March 9 to 13, 1905 * gives the following description of bathing in Franzensbad:

"An adult of medium stature, standing in

* Fellner, Leopold: "Zur physiologischen Wirkung der Kohlensäurebäder." Berlin. klin. Wochenschr., June 12, 1905.

the basin, is reached by the gas up to the hips. Persons taking a bath stand upright in the basin, so that the gas may not cause inconvenience in respiration. They are fully dressed. When using the bathing-tub, which is made of sheet iron, the persons taking a bath may remove their clothing except undergarments and stockings. The bathing-tub is provided with a frame and a lid, both of which have an opening to receive the neck of the patient. A towel serves to close the opening around the neck and to prevent the escape of gas and its interference with respiration. Persons taking a bath sit in the basin on a perforated, wooden chair. The feet rest on a wooden hassock, as the basin feels very cold. In order to prevent any injurious effect of gas escaping from the pipe, several excellent ventilators are provided at the windows as well as at the floor of the room."

I can not understand the necessity of some of the precautions, which must be very inconvenient to the bather in Franzensbad. I never was in Franzensbad. This description, given by Fellner, and which I saw only a short time

ago in the *Berliner klinische Wochenschrift*, is the first which came to my notice. After

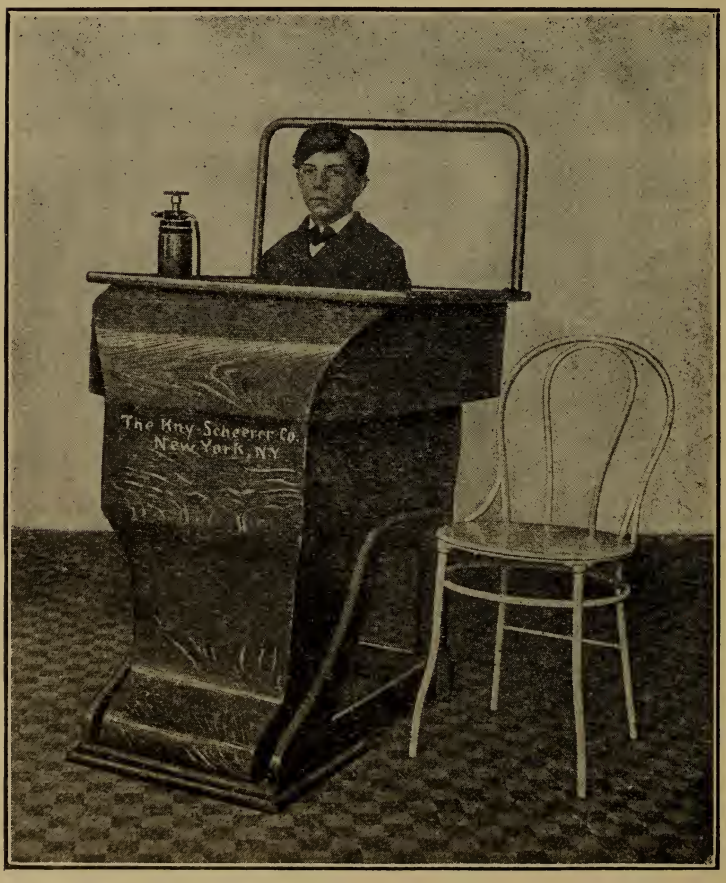


FIG. 4.—Rose's Carbonic-Acid-Gas Bath.

years of experimenting I had the bathing cabinet constructed which is represented by the

figure, a very simple contrivance made of metal. The gas is taken from an ordinary cylinder containing liquefied carbonic acid. The bather takes his seat in the tub; the gas is turned on and conducted through a rubber tube into the tub. A lighted candle is placed in the tub alongside the bather, the flame being on a level with the ensiform process or even a little higher; at any rate, below the level of the axilla of the bather sitting in the tub. The light becomes extinguished when the gas coming from the cylinder has reached it. Then the gas is shut off. Carbonic-acid gas is heavier than the air, and the bathtub is filled with the gas as it would be with water. The water as well as the carbonic-acid gas remains at the level given to them; but even if the gas should become agitated, or if the tub should be overfilled, it will run over the brim of the tub and sink alongside of it to the floor.

The lid and the towel, as mentioned, I found superfluous. No lid with an aperture for the neck can be made gas-tight; no towel will prevent penetration of the gas, but the gas will

not rise and lid and towels are worse than useless. Further, it is perfectly immaterial, as to the effect of the gas, whether the bather is dressed or undressed or partly undressed. The gas will penetrate through all clothing except rubbers. Rubber boots or shoes have to be removed.

Carbonic acid being a colorless gas, the tubs and basins to the eye appear empty. By the experiment with a lighted candle—the flame becomes at once extinguished in the gas—we can learn the difference between gas and atmospheric air. Carbonic-acid gas, about one-half heavier than atmospheric air, sinks to the bottom, and as long as the bather keeps the head above the level of the gas there exists no possibility of any harm.

The first sensation of the bather in the bath is that of warmth, beginning at the feet and extending gradually, by means of the penetrating power of the gas over the whole surface of the body exposed to it. This changes by degrees into a piercing or prickly sensation. As the gas by itself is cool, this sensation of

warmth is not due to the temperature of the gas, but is a consequence of the intense irritation which it produces, especially on the peripheral nerves, followed by increased circulation in the capillaries and manifested by reddening of the skin. The capillaries and arteries become dilated, the amount of blood in both, as well as the blood pressure in the arteries, is increased, and the diastole of the heart becomes more effective. These are moments of significance for the heart and its work, in so far as the intensity of the arterial circulation in general is augmented, the drawing of blood from the veins facilitated, the diastolic filling improved, and the heart muscle given more time for relief and for preparation for renewed energy.

In July, 1904, I published my experience with the carbonic-acid-gas bath.* I may be permitted to quote verbatim from this paper in

*"Effects of the Dry Carbonic-Acid-Gas Bath on the Circulation and on the Diseased Heart." New York Medical Journal and Philadelphia Medical Journal, July 9, 1904.

order to compare my observations with those given by Fellner. My paper reads:

"That the rapidity of the whole blood circulation increases during the bath is shown by the increased strength and volume of the radial pulse. The pulse of the bather, within a few minutes after having entered the bath, resembles a pulse stimulated by alcoholic drinks.

"Since I have not found in the literature a record of the effect of the dry carbonic-acid-gas bath on the number of the pulsations, I shall present one from my case-book.

"The bather remains in the bath for about twenty minutes, or a little while longer. The pulse is counted every five or ten minutes, as long as the bath is continued.

"The following case was that of I. M——, 20 years of age, suffering from neurasthenia, and the treatment was confined to the carbonic-acid-gas bath:

"First bath—Pulse 92, 80, 72. Second bath—88, 76, 72, 80, 88. Third bath—88, 72, 76, 68. Fourth bath—80, 72, 60, 68. Fifth bath—80, 80, 72, 60. Sixth bath—80, 76, 68, 72.

"In the next case, that of Mrs. H——, 35 years of age, a severe form of neurasthenia, strychnin injections formed part of the treatment during twelve days. However, it shows the effect of the gas application on the number of pulsations, or at least how the number varied during the bath.

"First bath—96, 104, 100, 116. Second bath—92, 108, 104, 88. Third bath—92, 88, 112. Fourth bath—104, 104, 84, 96, 92. Fifth bath—120, 100, 96, 100. Sixth bath—96, 92, 92, 96. Seventh bath—108, 100, 96. Eighth bath—88, 88, 92. Ninth bath—88, 88, 88. Tenth bath—104, 84, 92. Eleventh bath—96, 96, 92. Twelfth bath—88, 80, 80. Thirteenth bath—100, 88, 88. Fourteenth bath—104, 100, 92. Fifteenth bath—96, 96, 92. Sixteenth bath—88, 88, 84. Seventeenth bath—92, 88, 80. Eighteenth bath—88, 88, 92. Nineteenth bath—92, 84, 88. Twentieth bath—92, 88, 88.

"I wish to express my thanks to Dr. E. C. Dent, medical superintendent of Manhattan State Hospital, on Wards Island, for having

allowed me to introduce the carbonic-acid-gas bath in his hospital. I wish also to thank the members of the staff of this hospital who took interest in the method, especially Dr. C. H. Holmes, who permits me to report the following case under his care as he has recorded it in the books of the hospital, and to have the sphygmographic tracing taken by him reproduced:

"N. C——, married, 24 years of age. September 15, 1903—Pulse 82, sufficient force. One intermission to the quarter (¼). Impulse at apex marked; also a thrill. Apex beneath left nipple, fifth intercostal space, three and a half inches from median line. Very loud murmur at apex, carried to left axillary line. Mitral regurgitation. No direct mitral, no direct aortic, no direct pulmonary. Long heart with a dilated left ventricle.

"The sphygmographic tracings on following page furnish evidence of the effect of the carbonic-acid-gas bath on the heart.

"More such tracings were taken in different cases of heart disease. I give only this one,

however, because it furnishes conclusive evidence enough to establish the effect of carbonic acid.

"The Dudgeon sphygmograph was used in these tracings, the clockwork being regulated so that five inches in length equaled ten sec-

onds in time. The amount of pressure applied to the vessel was always the same both before and after the bath, three ounces being the average amount.

"Unless great care is used in both the manipulation and adjustment of the sphygmograph, the results derived from a series of experiments like these are likely to be fallacious and misleading. With the proper amount of care, however, directed to the general running order of the instrument, and its careful and accurate ad-

justment to the vessel, in the series of observations on any given case, the sphygmograph furnishes a safe guide as to the changes in rhythm, force, and frequency of the pulse. The comparison of the tracings taken both before and after the baths in this line of experiments shows the following changes in the pulse *after* the bath:

"Heightened arterial tension, shown by the broadening of the top of the percussion wave. Improvement in the rhythm of the pulse, shown by the obliteration of intermissions—the change as a rule from an irregular, poor-volume pulse to a regular pulse of good volume. Other changes have been noticed, but in the series, taken as a whole, none have been so constantly present as those above mentioned.

"To examine in a scientific way the effect of carbonic-acid gas, externally applied, on the pulse beat and blood pressure, to secure reliable sphygmographic tracings and measurements of blood pressure is difficult. Comparisons have constantly to be made to determine whether the effect is really due to the gas or, in some de-

gree, to manipulation. However, one thing is certain—there is a decided effect manifested by carbonic-acid gas on the circulation and I hope to be able to arrive at positive and exact results. Meanwhile, I shall be well rewarded if I have succeeded in attracting the attention of those who have facilities to follow the matter up."

The description Fellner gives of the effects of the gas bath is as follows:

"What are the manifestations taking place in the carbonic-acid-gas baths? Having entered the bath, a prickling sensation and a peculiar feeling of warmth are noticed. It rises upward to the height of the gas, gradually becomes more intense, imparting a sensation of heat which is especially noticeable at the perineum and the genitals. Finally, there is increased perspiration at these places. This sensation of heat continues for at least half an hour after leaving the bath. There is also a visible effect, the skin becoming hyperemic and turgescent where the gas has come in contact with it. Hemorrhoids undergo a swelling

and possibly there may be some bleeding. The sensation of prickly heat produces such an effect upon the sexual organs that there occurs sexual desire.

In giving an account of his investigations, Fellner states in detail the sensations experienced in the gas tub-bath. He says: "So far as I know, Kisch's observations are the only ones that have been made with regard to changes in pulsation and respiration.* On the question of investigating changes in blood pressure, I have no information. Kisch found the following: Measuring the pulse every five minutes, it decreased by four to six beats a minute after a lapse of ten minutes. This diminution of frequency lasted from fifteen to twenty-five minutes, after which there was an increase. When the bath has lasted for forty to fifty minutes, the frequency increases to more than normal, so that after a forty-five to sixty minutes' stay in the bath the increase over normal frequency amounts to four to eight

* The author has apparently not seen my article from which I have quoted above.

beats a minute. The frequency of respiration remained unchanged when the bathing-time did not exceed half an hour. After a prolonged stay, however, there was an increase by four to eight respirations a minute, accompanied by increased pulsation. This was followed by manifestations of congestions toward the head, a feeling of heaviness and pressure in the head, a feeling of anxiousness, perspiration at forehead and temples.

"I will now proceed to state the result of my investigations, which referred to frequency of pulsation and respiration and to blood pressure. So far, I have only conducted two investigations in the bathroom where persons remain standing. Preceding the first bath, I instruct the patient to sit down for fifteen minutes, after which I determine the frequency of pulse and respiration, and the blood pressure. I then let him rise and again determine the same particulars. As is well known, the pulse is accelerated when the person is standing, while the blood pressure is diminished. This is shown by the accompanying table, which records

Changes of Pulse, Respiration, and Blood Pressure while in the Carbonic-Acid-Gas Bath.

Position.	Date (1904).	Temperature of Atmosphere.	Barometer.	Temperature of Room.	Before the Bath.			In the Gas-Bath.						Difference.			Temperature of Room at the End of the Bath.	Temperature of CO_2 after 15 Minutes.	Remarks.
					Pulse.	Respiration.	Blood Pressure.	Duration.	Pulse.	Duration.	Respiration.	Duration.	Blood Pressure.	Pulse.	Respiration.	Blood Pressure.			
Standing in the Basin.	Sept. 9.	.....	....	.....	99	17	115	6′ 12′	102 102	7′ 13′	15 17	9′ 16′ 20′	130 125 130	+3	0	+15			
	Oct. 1..	.....	....	.....	99	16	120 120	10′	102 ...	12′ ...	17	13′ 17′ 14′	110 125 125	+3	+1	+5			
Sitting in the Gas-Bathtub.	Oct. 2..	14.2 C.	724	14.0 C.	88	18	105=16′ 115=18′	10′	100 ...	11′ ...	16	18′ 20′ 22′	130 135 135	+12	−2	+20			
	Oct. 3..	15.0 C.	725	14.0 C.	90	15	15′=110 16′=110 20′=115	10′	87 ...	12′ ...	15	20′ 22′ 25′	115 120 120	−3	0	+5	.....	.....	Respiration somewhat oppressed in the first minutes.
	Oct. 4..	15.0 C.	727	14.5 C.	94	14	17′=90 19′=95 21′=100 22′=95	10′	96 ...	12′ ...	16	18′ 20′ 23′ 24′	95 95 100 100	+2	+2	+5			
	Oct. 5..	12.25 C.	722	13.5 C.	97	14	10′=90 16′=100 19′=110 20′=110	11′ ...	92 ...	13′ ...	17	20′ 22 25′	120 120 120	−5	+3	+20	13.25 C.	14.5 C.	Conducting tube at first not completely opened, felt little warm.

Sitting in the Gas-Bathtub. Temperature of air — 4° to — 8° C.

Oct. 6..	.....	.....	...	....	.....	...	... ...	....	...	....	....	...	....	12.0 C.	13.0 C.	
Nov. 17	.....	12.0 R.	88	14	95, 100, 100	11′	80 10′	15	15′	120 120 120	−8	+1	+20	15.0 R.	.....	3:30 P.M., poor ventilation, leaking of gas-stove. Towel around neck very thick, therefore very warm.
Nov. 18	.....	12.0 R.	80	15	95, 95, 95	11′	82 12′	15	17′	110 110 110	+2	0	15	13.0 R.	.....	Very good ventilation.
Nov. 19	.....	12.0 R.	82	13	95, 95, 95	13′	86 12′	deep 14	18′ 20′ 22′	100 105 105	+4	+1	+10	16.0 R.	14.25 R.	Very good ventilation.
Nov. 20	.....	15.0 R.	83	14	90, 90, 90	10′	90 11′	15	15′ 18′ 20′	100 100 100	+7	+1	+10	17.0 R.	11.50 R.	
Nov. 23	.....	13.0 R.	100	13	90, 95, 90	12′	105 11′	15	15′ 17′ 20′	120 120 120	+5	+2	+27	12.5 R.	11 R.	
Nov. 24	.....	12.0 R.	96	14	95, 95, 95	14′	98 12′	13	17′ 20′ 22′	120 120 120	+2	−1	+25	13.0 R.	11 R.	
Nov. 25	.....	11.0 R.	88	15	95, 95, 95	16′	96 13′	16	20′ 22′ 24′	115 120 120	+8	+1	+25	13.0 R.	12.5 R.	

Changes Without Bath.

Sitting.			Upright.			Standing.			Difference between Sitting and Standing.		
									Pulse.	Respiration.	Blood Pressure.
90	14	105, 110, 110	98	15	80	13′ 102	12′ 14.5	15′ = 70 16′ = 70	+8	+1	−30

one of these experiments. Upon rising, there was an increase of eight pulse beats a minute; respiration had decreased by one breath a minute, and the blood pressure by 30 mm. When the upright position is maintained for a prolonged period, frequency of pulsation is still further increased, respiration remains almost unchanged, and the blood pressure sinks still lower.

"We will now return to our experiments. Frequency of pulse, when standing, was 99, respiration 17, blood pressure 115 mm. Then the person went to have the gas-bath. After six minutes the pulse was 102, after twelve minutes 102; respiration after seven minutes 15, after thirteen minutes 17. Blood pressure after nine minutes was 130 mm., after sixteen minutes 125 mm., after twenty minutes 130 mm. We therefore see that the frequency of pulse had increased by three a minute, respiration was unchanged, and the blood pressure had increased by 15 mm. In the second experiment the pulse after ten minutes' standing in an upright position was 99 a minute, respira-

tion 16 after eleven minutes, and the blood pressure 120 mm. after fourteen minutes. In fifteen minutes the latter was still 120 mm. In the gas-bath, pulse 102 after ten minutes, respiration 17 after twelve minutes, blood pressure 125 mm. after both seventeen and nineteen minutes. Therefore, frequency of pulsation had increased by three beats a minute, the number of respirations by one, and the blood pressure by 5 mm.

"But as these experiments did not take place under the same conditions as obtain in the case of CO_2 mineral baths, and as it was important to produce the identical conditions, I proceeded to conduct my investigations with gas tub-baths. The table shows the results of eleven such examinations. Before going into these details, I will describe the method according to which I made my observations and the sensations I experienced while taking these baths myself in the bathtub. The experiments were made in the beginning of October and at the end of November. In October the temperature of the open air was between 12.5° and

15° C.; the room temperature between 13.5° and 14.5°, so that no fire was needed. During the second half of November the outside temperature was between — 4° and — 8° C., the room was heated by a gas-stove at temperatures ranging from 12.5° and 16° R. I took a seat on a wooden chair in the bathtub, with extended legs, as if I were taking an ordinary water-bath. Before taking the bath I rested for fifteen minutes on a couch, occupying the same position which I afterward observed in the bath. Then pulse, respiration, and blood pressure were determined. I now entered the bath. The lid was closed and the aperture of same was closed with a towel. The gas was turned on, making much noise as it poured into the bath. The air escaped through an opening at the opposite wall of the room. I will now describe my sensations on the occasion of one of these experiments on October 3.

"After two minutes there was a sensation of warmth both in the lap and on the abdomen. After three minutes the sensation of warmth extended to the chest, and breathing was

slightly obstructed. After four minutes there was a sensation of warmth in the back and left leg, which was the side where the gas was admitted. After five and one-half minutes the sensation of warmth extended to the inner surface of the right leg, followed by an intense feeling of warmth over the upper part of the body, also in the arms. The hands were still cold, also the feet after six minutes. After seven minutes there was perspiration on the chest and back, sensation of warmth in the feet; and after eight minutes the hands slowly commenced to feel warm. Intense feeling of heat over the entire body. Sensation of obstructed breathing disappeared.

"I have taken notes of the sensations on several occasions. They were not always alike; but I will not take up time by describing the differences, but continue the description of the method of experimentation.

"After ten to twelve minutes' stay in the bath I counted pulse and respiration. Then the entire bath was covered with a large linen sheet, which was pulled over a frame under the

lid. Now the lid was removed and I placed my left hand—the same with which the blood pressure had been determined before the bath—carefully from under the linen sheet upon a small table, the height of which was on a level with my heart. After fifteen minutes' stay in the bath the blood pressure was taken by my son, who is very expert in these experiments; then again after eighteen, twenty, and twenty-five minutes.

"The results are chronicled in the table, showing that the blood pressure was raised in all experiments; the minimum was 5 mm., and the maximum 25 mm. In 2 experiments out of 13 respiration had decreased twice by one or two breaths a minute, 8 times it had increased by 1 to 3, and in 2 experiments the frequency remained unchanged. Pulsation decreased in 3 cases; once by 3, once by 5, and once by 8 beats per minute. In the second case possibly insufficient gas supply was at fault. Nor did I feel properly warm on that occasion. The attendant first forgot to turn on the gas, and later did so incompletely. In the experiment

on October 3, the opening of the lid was not properly closed by the towel. I breathed some of the gas and experienced slight dyspnea. In the experiment on November 17 there was possibly an escape of gas from the apparatus. There was bad ventilation, causing again some dyspnea and a feeling of weakness. I believe there is so much more reason for holding these causes responsible, as in later experiments, where ventilation was perfect, there never was any reduced frequency of pulsation.

"In ten experiments pulsation was increased. The smallest increase was two and the largest twelve beats a minute.

"The results, then, are as follows:

"In the CO_2 gas-bath the blood pressure is always increased; also frequency of pulse and respiration in a large number of experiments. This is not the case in the CO_2 mineral baths, in which I, and also others, have generally observed a decrease in frequency of both pulse and respiration. I have also observed that the blood pressure sinks during the bath, and re-

ported this condition in an address I delivered at the Congress of Balneologists of Austria, in Abbazia, on October 5, 1904. A. Schott, Ewald, Gräupner, Broadbent, Graigner, Leslie Thorne, Leith, Baltusewicz, have made the same observation. The temperature of CO_2 gas was taken by leaving the thermometer in the bathtub for fifteen minutes. The lowest was + 11° R., the highest 14¼°, while the maximum outside temperature was 12° to 25° C.; the minimum — 4° to — 8° C. Kisch found that the temperature of the gas in Marienbad at an outside temperature of over zero was lower by 0.5° to 1° R., and that in winter between — 4° and — 12° R. the temperature of the gas did not exceed — 1° R. The gas, therefore, has a temperature of its own, which is independent of the outside temperature.

"Seeing that the temperature of CO_2 in my experiments varied between 11° and 14¼° R., which is equal to an average temperature of 13.5° R., the relation of heat conductivity of CO_2 to that of atmospheric air is in proportion of 59 to 100. The slight difference in the heat

capacity between carbonic acid and air may be neglected—the result would give approximately the figure 23 as indicating the point of indifference of air. Therefore CO_2 appeared as warm as atmospheric air at a temperature of 23° R., a figure which exceeds by far the average point of indifference of the same.

"If, then, the frequency of pulse and respiration and the behavior of the blood pressure are different in a CO_2 gas-bath and in a CO_2 water-bath, the probable explanation is the difference in effect of the two component parts of the CO_2 mineral bath, namely, CO_2 and the water, in consequence of their different thermic point of indifference. This result may well be looked upon as supporting the theory of thermic effects of contrast as established by Senator and Frankenhäuser.

"If we wish to draw therapeutic conclusions from these results, we are justified in maintaining the following indications which had already been found out empirically: (1) On the part of the nervous system: anesthesia, hyperesthesia, neuralgia, and peripheral paralysis based

upon rheumatic, traumatic, or toxic causes; (2) functional disturbances of the sexual organs: amenorrhea, dysmenorrhea, impotence, and absence of sexual desire. On the other hand, the following would be contraindications: (1) Tendency to hemorrhage, menorrhagia, bleeding from hemorrhoids, hemoptysis; (2) chronic cardiac disorders, chronic affections of the lung, and irritability of the respiratory organs.

"I should like to derive two therapeutic points of advice from the investigations I have conducted. On the assumption that the CO_2 gas-bath does not interfere with the effect of other baths, mud-baths or steel-baths, that on the contrary it supplements the same, we have prescribed the same without scruples, to be taken shortly before or after the other bath. This position is also justified in attaining the desired effect, as, for instance, procuring menstruation, increasing sexual desire, etc. But as we have seen that the CO_2 gas-bath increases cardiac function and frequency of respiration, it would be advisable to prescribe a certain interval between the two baths so as not

to create any injurious effects by causing too great excitation of the heart; or in another case, not to interfere with the action of the other bath upon circulation and respiration."

Dr. Satterthwaite had the courtesy to compare with me at the Manhattan State Hospital, during the summer of 1904, in some cases the effect of the carbonic-acid-water bath on blood pressure with that of dry carbonic-acid-gas bath, and we found that they indeed corresponded.

Carbonic-acid-gas baths, as means of general invigoration and recuperation, may serve as substitutes for sojourning at watering-places in cases in which circumstances do not permit the business or professional man to quit his daily occupation.

In a case of progressive muscular atrophy, altho I did neither expect nor promise a curative effect, the patient derived much benefit from the carbonic-acid-gas baths, finding them more serviceable than electricity and massage. It is to be hoped they will become popular; they deserve to be.

As it is unnecessary to go to Nauheim for taking Nauheim baths, so neither is it necessary to go to Franzensbad for dry gas-baths. We can imitate the one as well as the other to perfection.

The action of the gas on the circulation is beneficial, not only in heart disease, but in many other conditions, even in health, as well.

After we have been in the dry carbonic-acid-gas bath for from twenty to thirty minutes, we feel remarkably refreshed and exhilarated; this sensation lasts for hours and can be compared with the effects of a sojourn at the seashore or in the forest.

Twenty-five thousand patients visit Nauheim, Germany, every season to take the saline carbonated baths. Most of these are cases of cardiac affections, but a great number are sufferers from gout, rheumatism, neurasthenia, and locomotor ataxia.

These natural springs at Nauheim contain from 2 to 3 per cent. of sodium chlorid and from 0.002 to 0.003 per cent. of calcium chlorid, besides small quantities of various salts of iron. By far, however, the most important in-

gredient is the large amount of carbonic acid in these waters. The waters from the springs in Nauheim rise from a depth of over 500 feet to a height of 56 feet above the earth. The springs are so richly charged with carbonic-acid gas that the area where they fall is a great white seething mass.

The artificial Nauheim bath is given by the American Nauheim Bath Company, 135 West Forty-fifth Street, New York, an institution under control of New York physicians.

Schott, of Nauheim, advances the theory that the chlorids of sodium and calcium of the Nauheim waters, together with the carbonic-acid gas passing through the epidermis, stimulate the sensory nerve-endings, and by a reflex action on the cardiac nerves cause the heart to beat more forcibly and less rapidly. It is, I believe, generally admitted that the skin has little power to absorb salts, even in solution; nevertheless it is quite possible that the carbonic-acid gas produces some chemical change in the salts in the solution by some method as yet unknown to us, and in this way

the salts may be absorbed; and there may be produced a physiological effect, not only cutaneous stimulation directly by the carbonic-acid gas, but in addition to this by the chemically changed salts by their absorption into the circulation.

On entering the bath for the first time the patient experiences a slight depressive feeling in the chest, but this is usually succeeded in a few minutes by a general sense of warmth and well-being.

Schott found that a plain brine bath alone increased the blood pressure from 5 to 10 mm. of mercury, and the saline carbonated bath increased it from 10 to 30 mm. He also found the Nauheim bath to be of diagnostic value. If in a given case the blood pressure was diminished after the bath, it indicated myocardial degeneration or pronounced arteriosclerosis.

Schott states that if the blood pressure is as low as 65 mm. of Hg in the sphygmomanometer the Nauheim baths are contraindicated. That the area of cardiac dulness is diminished by the Nauheim treatment there can be no doubt. It can be proved by auscultation and percussion, but it is made more patent by the *x*-ray picture.

Eichhorst speaks of one case of pronounced mitral insufficiency in which the *x*-ray showed the increased area of cardiac dulness. After two series of baths of forty minutes each, extending over a period of eighteen months, the patient was cured and accepted by a very strict life-insurance company.

Persons who are likely to derive the greatest benefit from the Nauheim baths are those having cardiac dilatation, due to overwork or worry. Other cases amenable to this treatment are the dilated, enfeebled, or irritable heart, coming on often after influenza, or the result of rheumatism or gout. Dr. Samuel G. Tracy, of New York, saw decided improvement in mitral disease where lack of compensation was threatened. Patients who have cardiac disturbance from excessive smoking, dissipation, etc., are markedly improved by the Nauheim treatment. In nearly all cardiac cases, unless they are relieved by rest, diet, and Nauheim treatment, the heart becomes overloaded and overworked; an impure blood-supply, congestion of the internal organs, and a progressive wrecking of the heart itself

follow. On the other hand, under intelligent treatment, including a series of Nauheim baths, the patients may have their lives prolonged for a number of years in comparative comfort.

The method of taking the Nauheim bath, as practised in the American Nauheim Bath Company of New York, is the following:

First, the patient is divested of his clothing; then the pulse is taken, after which he is put in the bath at a temperature ranging from 96° to 86° F., depending upon the case. As soon as the patient is submerged in the effervescent saline bath, millions of gas bubbles attack the nerve filaments in the skin, and the patient feels as if a very mild electric current were passing through him. This bath lasts from eight to twenty minutes, during which time his pulse is taken twice, and each time the number of beats is less per minute and the quality of the pulse stronger. Now the patient is enveloped in a large Turkish towel and dried, and he returns to his couch, where he rests from one-half to three-quarters of an hour or longer. This is followed in heart cases by the Schott

resistance movements, a sort of physical-culture exercise. These movements are given from five to fifteen minutes, and have nothing to do with gymnastics in the ordinary sense of the word. They, doubtless, in the end improve the muscles generally, but this is not their principal object. It should be distinctly understood that each exercise is designed to produce regular movements, with but little exertion and absolutely no fatigue. There are sixteen of these exercises, arranged either for upper or lower extremities, or for the trunk; and while they are made, the operator offers a slight resistance to each one.

During the exercises the patient should breathe regularly, and no limb or portion of the body should be so placed as to compress the blood-vessels and thus check the circulation.

The Nauheim methods with American adaptations are fully described and illustrated in Satterthwaite's book "Diseases of the Heart and Aorta."

While drugs, cardiac tonics, and stimulants may relieve urgent symptoms, the carbonic-acid baths, combined with the resistance exercises,

will give greater and more lasting relief than any other form of treatment.

It is only few persons with cardiac trouble who can go to Europe; and for those who find it necessary to stay at home, good results can be obtained in New York City by means of the artificial Nauheim baths.

There are different ways of preparing the artificial Nauheim baths. The best method is to charge the water with carbonic-acid gas by means of Kny-Scheerer's Zestoo apparatus. It charges the water thoroughly and efficiently with a high percentage of carbonic acid, is very economical in its operation, takes up very little space, is simple in its manipulation, is reliable and durable, and recommends itself on account of the relatively small cost. With the Zestoo apparatus (Fig. 5) a carbonic-acid bath can be prepared in a manner fully equal in effect to natural waters, as the exact dosage of carbonization can be varied at will.

The apparatus itself consists of two mixing cylinders, to which a cylinder of liquefied carbonic acid has to be coupled. The latter is

provided with a pressure-regulating valve; the hydrant water is connected with the mixing cylinder and liquefied carbonic acid is simultaneously injected, so that an intimate mixture

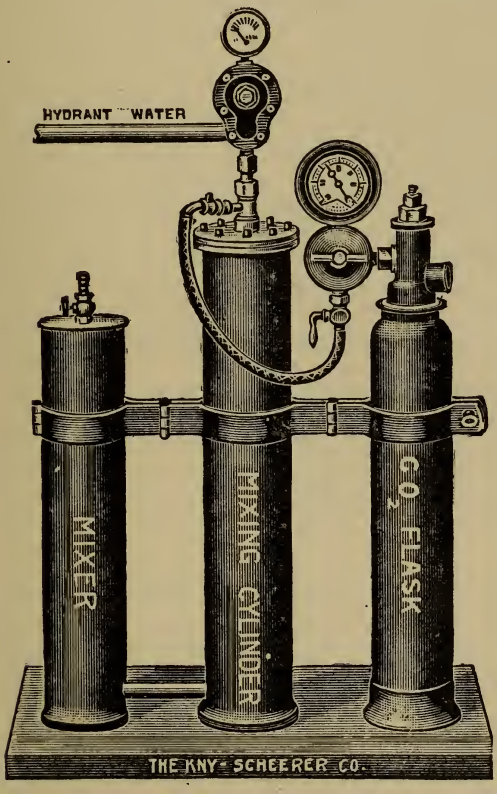


FIG. 5.—Zestoo Apparatus.

takes place in the interior of the cylinders, whence it flows into the bath-tub and the bath is ready for use.

CHAPTER IX

RECTAL FISTULA PROMPTLY, COMPLETELY, AND PERMANENTLY CURED BY MEANS OF CARBONIC-ACID APPLICATION

In January, 1903, I published in the New York *Medical Journal* my first case of successful treatment of rectal fistula by means of carbonic-acid gas application:

Case I.—I. A——, 34 years of age. Dancing master. Married; father of three children. Family history good. General condition fair. Active, industrious man; has, in spite of great suffering, worked very hard to support his family and aged and infirm relatives. He came to my office December 29, 1902, to be treated for fistula in ano. Had been suffering from constipation as long as he could remember. When

twenty-two years of age he became afflicted with hemorrhoids and these have given him trouble ever since. When the piles protruded he used to reduce them by means of a damp, hot cloth. In June, 1902, he noticed a discharge in the anal region. Before this discharge was noticed, and ever since, defecation was exceedingly painful, and there was always considerable straining. A bearing-down pain would sometimes last from six to seven hours, no matter what position he assumed—sitting, standing, or even lying down. There was also experienced a peculiar trouble on urinating; as soon as the desire to urinate made itself felt, the patient had to seek quickly a place of security, because with the desire to micturate ended all control over the sphincter vesicæ.

The patient was so nervous that he dreaded examination and I had to promise not to cause any pain. I found a fistulous opening posteriorly and within an inch from the anal margin near the median line, from which there was some discharge. As the opening was very small, I inserted a probe with great care, so as to cause as little pain as possible, but did not pass it through the whole length of the sinus,

because I had promised to cause no pain. The history and the appearance, however, convinced me that I had to deal with a complete rectal, or if you prefer it, anal fistula. I advised operation, as some colleagues, who had seen the patient before me, had also done.

After the patient had left my office it came to my mind to try the application of carbonic-acid gas, first, to make sure that there was communication with the rectum; and secondly, to see what effect the gas would produce when passed through the sinus.

Twenty years ago I had demonstrated *urbi et orbi* that carbonic-acid gas applied to inflamed mucous surfaces of the rectum, vagina, or nose, was an ideal remedy, and all my experience during the two decades since passed has confirmed my observation more and more. Altho I have published all I have noticed in regard to this method of treatment from time to time in different journals, in different countries, and in different languages, and altho I have asked many professional friends personally to give the method a trial, I have as yet heard neither a single confirmation nor a single

contradiction of my experience. I may, perhaps, be excused for this digression; it may serve to illustrate how difficult it is to introduce a novel idea.

An experience I had had in a case in which morphin injections had left numerous abscesses on the surface of the body where the needle had been used, and in which the carbonic-acid-gas current, turned on or rather into these abscesses, had had a prompt curative effect, after ordinary antiseptic treatment had been rather unsatisfactory, suggested to me to try carbonic-acid gas in case of fistula.

On December 30, 1902, I passed a current of gas through the external opening. There was no other pain than that caused by the insertion of the nozzle of a common dropper which I had attached to the rubber tube conducting the gas. The irritation of the external orifice caused by the insertion of the dropper caused a slight hemorrhage—perhaps one drop of blood. Except for this, the application of the gas gave rather a pleasant sensation. It passed through the sinus into the rectum, filling the bowel up to its full capacity and causing thereby the

agreeable sensation of warmth that is noticed when the gas is introduced directly into the rectum.

December 31. The patient spoke in most enthusiastic terms of the relief experienced. He felt like a new man. There was no discharge; the parts around the fistulous opening were, indeed, perfectly dry, which they had never been since June. The bowels had moved freely and there had been no pain on defecation. From that time to the present there has never been any abnormal condition on micturition. The soreness of the tissues around the fistula had disappeared. Only a little blood from the granulations on inserting the nozzle.

January 1, 1903. Gas applied. There had been no pain or straining with defecation.

January 2. Gas applied. He had passed hard fecal matter, straining at the beginning of defecation; but by no means to be compared in severity with what he had experienced formerly. Before the gas treatment he had been unable to clean himself after stool except by dashing water over the anus, the parts were so sensitive; now he could use toilet paper. No blood on inserting the nozzle. From the first application the sinus began to close, and with the

third, very little, if any, gas passed into the rectum.

January 3. No discharge from fistula. Patient had had difficulty with piles. Feces had been hard. Piles protruding. Rectal cone, to reduce the hemorrhoids; compound licorice powder to soften feces.

January 5. The application of the gas current into what was left of the sinus brought away a plug of thick, yellow pus the size of half a pea, or less. It was demonstrated to-day that no gas entered the rectum.

January 6. Had had considerable pain on defecation. Bowels had been very loose, diarrhea-like, the result of the licorice powder. The pain was felt at the outlet of the former fistula. There was some thin matter and some thick, from the rest of the sinus. Absolutely no pain any more, except during defecation.

January 7. No evacuation of bowels. Fistula closed.

January 8. Hard stools; great straining, but without pain.

January 9 and 10. Gas has been applied daily to the fistula since January 1, up to the present date, when it will no longer enter. The rectum is now to be inflated daily with

carbonic-acid gas, to heal the internal ulceration, if such is present. Regulation of stool by means of compound licorice powder. Rectal cone to reduce the hemorrhoids.

I confess I have not had the opportunity to make a thorough examination of the rectum, either digitally or by means of the speculum or proctoscope, but for practical purposes I may arrive at the exact diagnosis *ex juvantibus*. It appears to be a case in which hemorrhoids became ulcerated; this ulceration caused abscess and the abscess caused the fistula.

January 12. I have to-day seen this patient, who describes his present condition as one of elysium compared with the past. Formerly, he was unable to sit down long enough for his meals; his agony was very great, and he had suffered thus for years. Now he has no pain whatever, on defecation or otherwise. His bowels move painlessly once or twice a day. He is still taking the licorice powder, and inflating the rectum, but the rectal cone has not been since applied, as the hemorrhoids have given him no further trouble. I advised him, however, to continue its use to reduce the hemorrhoids. *The fistula is completely and entirely closed and healed.*

January 22. All these days patient has been free from pain, bowels have moved regularly. Digital examination revealed considerably enlarged but soft, almost fluctuating prostate. Upon inquiry I learned of a gonorrhea that the patient had had twelve years ago. Ordered introduction of rectal cone with warm water passing through it several times a day.

January 27. No more trace of fistula but cicatrix. The introduction of the rectal cone had been difficult, on account of a resistance (by the prostate), the bowels had been inclined to constipation, and defecation was sometimes painful. Urine passed into two glasses furnishes conclusive evidence of prostatitis; the one in the first glass being turbid to a high degree, the one in the second perfectly clear.

My second case was that of a tuberculous fistula, but here the carbonic-acid gas did not have a curative effect. The same negative results I had with complicated fistulas with multiple sinuses and numerous openings through the skin, mucous membrane, or both, where the sinuses extended for a considerable distance beneath the mucous membrane, par-

tially or completely around the bowel or to distant organs, as it occurs most frequently in syphilitic or tuberculous subjects.

Only in cases of simple complete fistula with two openings, one upon the surface of the body in the neighborhood of the anus and the other in the rectum, that is, the most common form of rectal fistula, have I succeeded.

The last case I treated successfully is the following:

A. H——, 59 years of age, tailor, father of a large family, came to my office October 16, 1904. Complete rectal fistula, five centimeters to the right from anus, discharging for one year pus and serum, and causing much pain. The probe entered the rectum in straight direction. Around the external orifice of the fistula the tissues are very much indurated, almost callous. Carbonic-acid gas introduced into the sinus entered the rectum. Patient lives at a great distance from my office, and came only in intervals of three days to have the gas applied.

After the third application no more gas entered the rectum. When he came the fourth time, the tissues around the external orifice had

lost their induration almost completely, and the sinus was so shallow that hardly any gas could be introduced. Having been at my office six times, I dismissed him, perfectly cured from his trouble, and when I saw him last, during the month of December, I learned that the cure has been a permanent one.

As I have demonstrated as long as twenty-two years ago, carbonic-acid gas applied to inflamed mucous surfaces of the rectum, vagina, or nose is an ideal remedy, and all my experience during the two decades since passed has confirmed my observations more and more. The local effect of the carbonic-acid gas on ulcerated surfaces is twofold. By its anesthetic action it relieves pain and tenesmus, and by its stimulant action on the circulation it is healing.

The only drawback which seems to be in the way of this treatment becoming favored by the great specialists on rectal diseases is that it is too simple, too rational, and its explanation too clear.

All that is required is the simple gas generator, a glass bottle with a wide neck and a rub-

ber stopper perforated so as to admit a tube with a nozzle, in which the carbonic-acid gas is generated by means of a solution of bicarbonate of soda and crystallized tartaric or citric acid (see Fig. 2).

It may be of interest to those who are not familiar with the history of the treatment of rectal fistula to read the following little historical sketch:

Hippocrates taught to treat fistula in ano by means of ligature. Galenos and his pupils were opposed to this method, and substituted extirpation. The surgeons of the seventeenth century considered the cure of a fistula a very difficult task, because they were of the opinion that such a cure could be accomplished only when all pathological, that is, all indurated, tissue would be completely destroyed. The operation had become a very barbarous one, consisting in extirpation of the fistula and all the callosities of the rectal wall in its neighborhood, by means of the actual cautery or some chemical caustics. The consequence was, the patients thus operated on who survived the oper-

ation, who did not die in consequence of hemorrhage or pyemia, were either not cured or were left with incontinentia alvi, or anal stricture. They were in worse condition than before the operation. The after-treatment was as complicated as the operation itself.

For this reason the operation of rectal fistula was much dreaded, and the physicians took all possible pains to cure fistula by other means—ointments, baths, and internal remedies—but, as a rule, without success.

This condition of things explains the fear of Louis XIV., who in the year 1686 was suffering from rectal fistula, and consented to the operation only after all other possible remedies had been tried in vain on many of his subjects suffering from the same evil. He was operated on by his first surgeon, Felix, who invented a new knife, which was afterward called the royal knife. The operation, performed November 21, 1687, was a success.

Dionis, who has reported all details of the case, tells us that afterward many people, not only of the royal court, imagined themselves

suffering from the same affliction as their king, in order to have the honor of being cut with a knife which bore the royal name.

Only after Pott, in 1765, had taught that the callosities need not be destroyed, and that a simple incision was sufficient to heal the difficulty, did the operation lose its danger and its horrors. Yet, Syme, in the year 1854, complains that there still existed surgeons in England who could not be persuaded to abandon the old method, and that he had seen several cases of frightful destruction, which had been caused by rural surgeons operating for simple rectal fistula.

Again and again have means been tried to cure fistula without operation. None has been successful, but here now is a problem solved which has vexed physicians for thousands of years.

The cases of complete cure of rectal fistula I demonstrated before the German Medical Society of New York, January 2, 1905. In the first case two years, and in the second two months, had elapsed since the complete closure of the fistula.

CHAPTER X

CARBONIC ACID IN CHRONIC SUPPURATIVE OTITIS AND DACRYOCYSTITIS.

1. Otitis

Knowing from history that carbonic acid had been successfully employed in purulent otitis, I was anxious to see it tried in this affection. Dr. Duncan Macpherson, to whom I suggested such trial, had the courtesy to comply with my wishes, and I am indebted to him for the following notes of three cases which he has treated in the outdoor clinic of the New York Post-Graduate Medical School. The apparatus used by Dr. Macpherson was the new cylinder of the Kny-Scheerer Company, which contains about two pounds of liquefied carbonic acid and which works to perfection, as the current of gas can be accurately regulated. The gas is

passed through a catheter introduced into the Eustachian tube.

The first case was that of a girl 9 years of age, who had a running ear for nine months following scarlet fever. The treatment consisted in sterile-water syringing at home, at first every four hours, as the discharge became less profuse three times a day, then twice a day, and finally once a day. Carbonic-acid gas was employed in the clinic twice a week. The discharge was arrested in three months. She had not been treated before she came to the clinic.

The second case was in a girl 7 years of age. Discharge followed an attack of influenza six months before. Treatment was the same as in the first case; it lasted two months. Discharge lessened greatly, and, according to a recent report made by the mother, it has now ceased entirely.

The third case was in a boy. Discharge followed opening of the mastoid process for cure of empyema. The operation had not been successful. This case has been under treatment for about four months. Necrotic bone is present, and the carbonic-acid treatment has, as it appears, not done any good.

No microscopical examination of the pus has been made in any of these cases.

2. Dacryocystitis

During spring, 1905, I was attending some patients, man and wife, who came to my office from some distance, from the State of New Jersey. They incidentally told me of their son, twelve years of age, as being afflicted with purulent dacryocystitis. He had been treated during eighteen months in some New York ear infirmary, had been operated upon and frequently probed. The purulent discharge, however, had persisted. I induced the parents to bring the child to my office. Judging from the effect of carbonic acid in cases of rectal and other fistulas I decided to try it in this instance, being convinced that no possible harm could be done thereby. I introduced it from my simple gas generator, to the tube of which I had attached an ordinary dropper. The gas current directed into the lacrimal canal brought up a great amount of pus, but caused no discomfort to the patient. I entrusted the

parents with this simple method of treatment. I saw the patient at weekly intervals twice again and convinced myself that the inflammatory symptoms had subsided, that there was no more pus. As the parents told me, there had been none since they had applied *daily*, according to my instruction, the carbonic-acid current.

I can not make a report of the final result as the parents, not appreciating perhaps the extraordinary interest I took in the case, did not give me any other information than that the improvement had been great, that altho there was some lacrimal humor occasionally, there had been no more pus.

Being anxious that this observation should be verified by an ophthalmologist, I addressed myself to Dr. Frank Newton Irwin, who, like Dr. Macpherson, had the courtesy to give the carbonic-acid treatment a trial in the clinic of the New York Post-Graduate Medical School, and who also had the kindness to give me the following notes of two cases:

Mrs. F. D——, aged 56, has had recurrent attacks of purulent dacryocystitis for ten

years. Says she had been operated on and probed at irregular intervals during these ten years. Came to the clinic first two years ago. Dr. Irwin found the lacrimal canal closed; he could not introduce a fine probe. Pus could be squeezed out by making pressure upon the lacrimal sac. The canal was then opened into the nose with Bowman's knife, and twice or thrice a week the canal was probed into the nose with large probes. Probing was frequently accompanied with application of silver nitrate, argyrol, and other solutions. While drainage was kept free the purulent discharge persisted. Four months ago (*i.e.*, in March, 1905) Dr. Irwin commenced carbonic-acid treatment, introducing the gas from the Kny-Scheerer cylinder, to which the tip of a lacrimal syringe had been attached, into the sac and nose. He used the gas twice a week for three months, at the end of which time there was no more pus.

Miss S. H——, aged 25. Says she had lacrimal abscess six years ago. Was treated by ordinary methods of probing. Pus always present. Treatment kept up for several months. Abscess would recur. When Dr. Iwrin first saw this case the lacrimal sac was full of pus,

draining out through a fistula on the face, half an inch below lacrimal opening. He treated this case for several months by probing, making irrigations, and applying astringents, but could not get rid of the pus. Commenced using carbonic-acid gas about three months ago (April, 1905). The gas was introduced through the tip of a lacrimal syringe—into the fistula, into the sac, and into the nose—twice a week for three months. Result, no more pus. Probing was continued in both cases.

CHAPTER XI

CARBONIC-ACID-GAS APPLICATION IN RHINITIS.

JOHN KANOLD, in the year 1708, wrote: "It is to be hoped that at this time no one who has common sense will deny that the *historia morborum* is the most important and most valued support of the whole of medicine, because, by thorough knowledge of this history, we learn to arrive at the true pathologico-etiologic conception, and consequently we find the necessary and reliable *indicationes curativæ*."

The historical chapter demonstrates how well these words of Kanold apply to the present conditions. From the history of the carbonic-acid treatment we can learn a great deal to find the necessary and reliable *indicationes curativæ* in regard to rhinitis.

Percival, as mentioned in the historical chap-

ter, successfully treated ozena by local applications of carbonic-acid gas. It was brought in contact with the nasal cavities through tubes. He speaks of this remedy as the best means of curing the offensive odor of ozena. Many physicians of the eighteenth century have used and recommended it in the treatment of ozena, but in our modern literature this is not even mentioned, altho Demarquay again, in the middle of the nineteenth century, wrote: "The gas douches (carbonic acid) modify and promptly cure the morbid discharges of the Schneiderian membrane." Except in the writings of Demarquay I did not find records of new observations of the employment of carbonic-acid gas in rhinitic affections until the quite recent publications of Dr. Joal, a French physician. He found that the gas acted as a vaso-constrictor, as an anesthetic, and as an antiseptic. He describes the effects as follows: When the gas is brought in contact with the nasal mucous membrane it produces at first a prickling but quite tolerable sensation, followed by an agreeable, refreshing effect of warmth and dryness. The

examination of the mucous membrane shows reduced sensibility to such an extent that otherwise painful cauterizations and explorations will cause no pain; then follows excitation of the nerve ends, producing vasomotoric dilatation and glandular hypersecretion; after this nervous activity becomes exhausted, the vessels become constricted, and again anesthesia will be noted.

The best results were observed in the treatment of hyperesthetic rhinitis, especially in that form which characterizes hay fever.

In case the application of the gas does not cure completely vasomotoric coryza, it will at least ameliorate to a marked degree the inflammatory symptoms.

Dr. Joal believes also that the employment of carbonic-acid gas is indicated to combat the microbic element of hay fever; he believes in the antiseptic effect of carbonic acid in these instances. I have not been able to see the original of Dr. Joal's report. In the extract from which I quote, nothing is said upon which facts Dr. Joal bases his theory. All I know is

that carbonic acid as an antiseptic is of limited value. I may be permitted to repeat here what I said in the chapter on dysentery. When antiseptic principles were first established in the treatment of wounds, all wound remedies were tried as to their germicidal powers. In regard to carbonic acid we know now that certain bacteria can live and thrive in it almost as well as in atmospheric air; that others develop imperfectly or slowly, and that a third class grows in it only when the cultures are exposed to breeding temperature. Saprophytes, altho they do not thrive in it, do not perish in carbonic acid. It does not affect the bacillus of typhoid fever, but it destroys the bacteria of anthrax and cholera. It interested me very much to learn from Dr. Alice Byram Condict, of Bombay, India, one of the matriculates of the New York Post-Graduate Medical School, while I was lecturing on carbonic acid before the class, that the physicians in India—the home of the cholera—insist strictly that people should drink no other water than that charged with carbonic acid.

According to Joal's and my own experience carbonic-acid gas is to be regarded as a remedy of the first order in the initial stage of an ordinary rhinitis, but in all forms of rhinitis as a means to ameliorate the intensity of the symptoms.

Finally, he describes a case of anosmia which he cured by means of carbonic-acid-gas applications.

It is impossible to exaggerate when I speak of the gratifying effect of the nasal carbonic-acid-gas douche in case of children, even in infants; but most of all in naso-pharyngeal diphtheria. Here it surpasses by far the methods of irrigation or syringing, which are so disagreeable and by no means harmless. While children will struggle and rebel against the syringe and irrigator, they like the gas application so much that they ask for it after they have once experienced the pleasant effect. The nose becomes cleared of the accumulated mucus and matter, and the little patient can keep the mouth closed and breathe freely through the nose. They apply the nozzle

themselves as soon as they again feel the necessity for relief.

A curious observation which will prove of importance if it becomes confirmed in more instances is this: I found that patients once treated for some length of time with nasal carbonic-acid-gas douches lost the vulnerability of the Schneiderian membrane, inasmuch as they no longer suffered from their accustomed rhinitis during the cold season.

The first apparatus which did good service and which has the advantage over the others that it can be easily improvised, as a rule, with the aid of a near-by druggist, consists of a bottle, holding a pint or a little less, with a wide neck and a rubber stopper perforated so as to admit a tube, with a nozzle, as the case may be, for nose, rectum, or vagina. A solution of about 6 drams of bicarbonate of soda in about 6 or 8 ounces of cold water is introduced into the bottle, and 4 drams of *crystallized* tartaric acid (if pulverized acid is used the development of the gas goes on too rapidly) are added. The larger these crystals are the bet-

ter. Instead of the tartaric-acid crystals, discs of acid sulfate of soda may be used. It may be easier to find large citric-acid than tartaric-acid crystals in the drug-stores. It is of course immaterial which of the two we choose. The bottle is then closed, and the carbonic acid developing in the water rises through the tube, the nozzle of which has been placed in position. This form of gas generator serves quite well to apply the gas to the nasal cavities, to inflate the rectum, and in some instances it can be used to give vaginal gas douches (see Fig. 2). Gas develops during about ten to twelve minutes. Its disadvantage is that the current of gas can be neither regulated nor interrupted.

A much better apparatus, especially convenient for use in our office, is the one represented in Fig. 1, made by the Kny-Scheerer Company, consisting of a gas-drum containing about two and one-half pounds of liquid carbonic acid. The current of gas passing through a tube (leading into a wash-bottle as shown in the cut) attached to the drum can

be regulated to a nicety and its strength watched with exactness.

Both contrivances are of great simplicity, and there can be no reasonable objection to introducing them into practise.

CHAPTER XII

MISCELLANEOUS.

W. Duffield Robinson attended a large number of patients suffering from purpura. The majority were prisoners who had been subjected to abstinence from meat for a long time.

He noticed in the case in which he had Bergeon's enemata administered a prompt disappearance of the affection of the skin, and thereupon he applied these inflations in a number of purpura cases. Some of these patients recovered within four weeks, while those treated with tonics alone often required many months of treatment.

Carbonic acid is the refrigerating fluid preferred for this purpose at Neisser's clinic at Breslau. The surface is sprayed with the carbonic acid as when making frozen sections. The broad perforated nozzle of the vial is

held about one centimeter from the skin, and the fluid is forced out by a bulb. In half a minute the skin is frozen hard. There is anemia at first; this is followed by intense hyperemia, and half an hour later by profuse serous transudation. In twelve hours an inflammatory redness develops, with blisters. When the freezing has been very intense, actual ulceration may follow. When it is necessary to repeat the application, an interval of five to ten days is interposed. Three sittings in less than a month are generally sufficient. This method of treatment proved particularly effectual in nine cases of lupus erythematodes thus treated. From three to nine applications were made and the patches healed remarkably promptly, but traces of recurrence became visible after a few months, showing that the refrigeration needs to be combined with some other measure to insure permanency. According to Neisser the ideal combination is with crude hydrochloric acid, according to Dreuw's technic, substituting carbonic acid for the ethyl chlorid. Tuberculous skin affections are evidently the chosen

field for this mode of treatment when phototherapy is impracticable for any reason. A lupous patch about six months old, on the forearm, healed with a keloid cicatrix after two applications of the carbonic acid and hydrochloric acid. In another case, two lupous patches on hand and arm ulcerated at first under three weeks of the combined treatment, but then healed over smoothly. All were favorably influenced and apparently cured to date. The experiences at the clinic were with psoriasis, primary sores, leg ulcers, and sycosis, besides the tuberculous affections. The primary sores all healed rapidly after a single application of the refrigeration and hydrochloric acid, before mercurial treatment had been instituted.

The results of the Nauheim treatment in diseases of the heart and circulatory system have stimulated investigations into methods of obtaining artificial carbonated thermal baths. R. Hatschek describes such a method in the *Wiener klinische Rundschau* (January 28, 1900). He quickly applies a paste of bicarbonate of soda to the body of the patient and fol-

lows this with wrapping him in a cloth saturated with weak hydrochloric or acetic acid. By occasionally wetting this cloth with the acidified water, a very lively effervescence is produced and the evolution of carbonic acid is well developed. It is claimed as worthy of notice that the production of the gas goes on even within the skin, for the paste finds its way through the pores and meeting the acid secretions of the sweat and sebaceous glands is converted into carbonic-acid gas. The gas evinces its efficacy directly upon its production by its action on the capillaries and nerve-endings in the skin. Beyond this, its too great activity is somewhat hindered by the cloth wrapped about the patient. The action of the gas is shown by the originally constricted blood-vessels and cold, cyanotic extremities returning to their normal state and assuming a ruddy, healthy glow. The rubbing and other forms of friction take much longer to accomplish this same result than does the gas when formed in this way. For one application for an adult, about two ounces of sodium bicarbonate were found

necessary, producing at the ordinary temperature of the room nearly 16,000 cubic centimeters of carbon dioxid. In preparing the paste several teaspoonfuls of warm water should be mixed with it in order not to chill the body before the cloth is applied. The application must be made hurriedly and the parts of the body may remain covered alternately, while the others are being treated with the paste. The acidified solutions are to be markedly thinned and diluted in order that no inflammatory reaction on the part of the skin should follow.

Ewart, of London, maintains that carbonic-acid inhalation treatment brings within the scope of Nauheim therapeutics a considerable number of cases that would otherwise be set down as unfit; indeed, he attributes much of the efficacy of the Nauheim bath treatment to the incidental inhalation of carbonic-acid gas. Whereas balnear treatment exercises its greatest influence over the period of recuperation, the inhalation treatment is indicated in the stage of failing cardiac energy. Ewart claims that those cases will derive most benefit in

which the elements of respiratory distress and cardiac pain predominate. Like many other drugs that in large doses possess a toxic and baneful effect, carbonic-acid gas has in lesser doses an active physiological effect. It would seem that none of the carbonic gas inhaled passes directly into the blood stream, but by raising the partial pressure of that gas in the lung prevents the liberation of some portion of the same gas already in the blood. Short of the asphyxial state induced by large doses of an irrespirable gas, Ewart enumerates the following as the chief physiological effects of smaller doses of carbonic-acid gas, inhaled experimentally in moderate concentration: (1) A feeling of internal warmth, and after a time some flushing; (2) a strong desire to breathe, and particularly to breathe out; (3) an excited state of the circulation, which may amount to throbbing or palpitation; (4) a slight giddiness and headache supervening after a while in some susceptible subjects; (5) general anesthesia is not brought about by moderate inhalations; (6) cutaneous anesthesia has been

obtained not as a result of the inhalation, but only by the local action of the gas upon the skin. Side by side with these effects of inhalation of carbonic-acid gas on the healthy subject, Ewart sets the observations of its effects on patients with cardiac symptoms. The subjective effects are: (1) Rapid diminution or cessation of cardiac distress or pain; (2) a feeling of increased freedom of respiration. The objective effects are: (3) A visible increase in the depth of respiration; (4) a marked improvement of the pulse; (5) an obvious improvement both in the complexion and expression of more than transitory duration; (6) by systematic repetition progressive improvement in the patient's general condition, as well as in the cardiac and respiratory functions. Thus it will be seen that the direct effect upon the cardio-vascular system is reenforced by the greater range of respiratory movements, which, so to say, open up wider channels by which the blood may find its way through the lungs.

CHAPTER XIII

THE CONTINUOUS WARM BATH

We have seen how the effect of the warm-water bath has many similarities with the effect of carbonic-acid baths—either dry or watery—and it appears opportune to devote a special chapter to the comparatively modern therapeutic measure, the continuous warm bath.

Considering this bath as a therapeutic means, we find that fixed laws to govern its employment are yet to be determined, and much which is known is to be complemented in several directions. However, some facts, founded on experience, have been demonstrated already on a scientific, a physiological basis. Of hydrotherapeutics in general it may be said that many rational facts, found by scientific research, would be retained if numerous as yet isolated truths of experience would have been

appreciated according to their value, instead of being lost to memory and to practise.

To demonstrate the effect of the continuous warm bath on innervation and circulation I may be permitted to describe a case which I presented before the New York German Medical Society, May 2, 1892.

Delia G——, 24 years of age, always well before, and of remarkably strong muscular development, was taken ill toward the end of September, 1891, with inflammation of the left elbow-joint; there were unusually severe symptoms of inflammation, especially violent pains. Several antirheumatics given brought little or no relief; even antipyrin, which at that time was the favored remedy, did not ease the pain or procure sleep for the night. Of all the remedies employed it was only the plaster-of-Paris bandage which gave some satisfaction. I left this bandage on for a fortnight, and a second time for ten days on the arm, and removed it when I had reason to suppose that the symptoms of inflammation, viz., swelling, pain, and increased temperature, had subsided. This proved to be the case when I removed the plaster-of-Paris.

Soon after removal of the first bandage symptoms of inflammation reappeared; after removal of the second, stiffness of the joint remained. It was only while the patient was under the influence of chloroform that I was able to bend and to stretch the arm. While I made these forced flexions and extensions, frictions, the symptom of synovitis fibrinosa, could plainly be felt. The forced flexion and extension under the influence of chloroform gave no permanent result. On the contrary, the exudation in the synovial cavity increased, and mobility was reduced to a minimum. The perisynovial soft parts became infiltrated, and and still more restricted the slight mobility.

At this time patient could not and would not remain with the family that had hired her to do general housework, and on November 30, 1891, she became an inmate of a hospital of this city.

One of the physicians of this institution told me that according to his opinion the prognosis in regard to the usefulness of the arm of my patient appeared doubtful. The treatment, he informed me, consisted in forcing the joint, which could be brought to a right angle with difficulty, by means of graduated bandages into an acute angle. The patient said that during

her stay in the hospital she took no medicine of any kind.

On December 12, 1891, she left the hospital. I now found the arm in the same condition as before she entered the hospital. To bring the joint from an obtuse to a right angle gave the patient considerable pain; and to go further in the way of flexion I regarded as too risky.

On December 15, 1891, I had the arm submerged in a warm bath, the bathing-tub consisting of an oval-shaped wash-boiler. I ordered some water taken out hourly and hot water added to keep the temperature as high as would be consistent with the patient's comfort. For the night moist compresses covered with flannel bandages were substituted. No medicine was given while the arm was treated by permanent submersion.

The patient had followed my orders only too conscientiously. She had taken the water so hot that it scalded hand and arm, and the epidermis became raised in the shape of numerous blisters. I did not place much stress on this accident, because, according to my experience, the warm bath simply continued would be the remedy for the effects of the too hot bath.

Such proved to be the case. No pain or ill consequence of any kind followed.

The effect of the permanent bath was highly gratifying. All pain the patient had been complaining of ceased at once. From day to day I could make more extensive flexions and extensions of the arm without causing violent pain to the patient. The comparatively slight pain which I caused now while making passive motions disappeared very soon when the arm was submerged again.

On the third day the patient herself could bring the elbow-joint to a right angle, the following day she could do this without causing any pain. On the fifth day she brought the joint to an acute angle, and on the tenth day flexion and extension were normal.

Since that date (December 26, 1891) patient has been attending to her housework, and she is able to do washing and ironing for the household. Unfortunately she is still exposed to the danger of rheumatic invasion, and from time to time new rheumatic attacks in the elbow-joint supervened.

Since then, whenever new rheumatic inflammation has set in, the case has been benefited by salipyrin. However, when pain and other

symptoms of new inflammation appeared, I ordered the arm to be placed in the warm bath for one or two hours at night, and the result was invariably that this relieved the pain.

I have to confess that when I presented the case the arm could not be flexed quite as far as the sound one, also that there existed a minimal swelling at the elbow-joint; but I am convinced that if the patient would have desisted from work and for days employ the warm bath, and, above all, be removed from all causes of new rheumatic infection, these comparatively slight remnants of rheumatic inflammation would have disappeared completely.

The continuous warm bath is employed in Leuk, in the canton of Wallis, 1,415 meters above the sea, situated in a ravine with grand Alpine scenery. The water of the springs is of 41.5° and 51° C. (170° and 123° F.) temperature, and contains sulfate of lime, sulfate of magnesia, and other salts, besides a small trace of carbonic acid. As a bath it is to be classified as an indifferent therme—the sulfate of lime is neither absorbed nor can it irritate

the skin—on account of its being contained in the water in too small a quantity.

The average course of treatment is calculated to last twenty-five days, during which time either every second day or every day the patients bathe once or twice during the day. The duration of the bath is in the beginning one-half hour, and is increased gradually to five and eight hours, divided between forenoon and afternoon; after eight to twelve days of gradual increase there is gradual reduction of the duration of the bath until the initial bathing-time has been reached. Ladies and gentlemen bathe at the same time in one common basin, the size of which is calculated for twenty persons. The bathers pass the time in conversation, reading, and playing dominoes on floating little boards. At noon the basins are partly, and at night they are completely, emptied and replenished. During the night the temperature of the water sinks to about 35° C. (95° F.). The diseases treated thus are gouty and rheumatic exudations, chronic exanthemata, psoriasis, eczema, prurigo.

Hueter recommends in polyarthritis synovialis acuta (rheumatismus articulorum acutus), after the acute stage has passed, and also in polypanarthritis (arthritis deformans), therapeutics which aid absorption and excite circulation, and praised, as the best means to this end, permanent warm baths, for either arm or leg, in tubs of proper size and shape, or general baths, as the case may require. He states that this therapeutic measure in polyarthritis synovialis chronica, as well as in polypanarthritis, had not been surpassed by any other method of treatment. He says: "In regard to polypanarthritis it is well known that no remedy is perfect, not even the permanent bath, but the permanent bath gives more satisfaction than all the other remedies."

Riess recommends permanent warm baths in articular and muscular rheumatism; he spreads a bathing-sheet, like a hammock, above the bath-tub in such a manner that the patient may rest on this sheet in the water. The read rests on a rubber ring.

It is a well-known fact that a warm bath of

long duration is mostly well tolerated. To emphasize this fact I shall give an extract of a communication from Dr. Baelz* on the permanent thermal baths of the Japanese: "The Japanese bathe in indifferent or slightly salty, thermes of 42° to 48° C. temperature, ten to fifteen times daily. Of special interest is a rudimentary bathing establishment situated in the mountainous region of Dzooshin, named Kawanaka. It is an Indian therme of 36.2° C. The patients remain in the water not only whole days, but for weeks at a stretch. They leave the water only to attend to calls of nature, or occasionally to take a little exercise. The body is placed in a half-recumbent or otherwise comfortable position, the occiput and neck rest on the margin of the wooden basin, in which a number of patients at the same time are gathered together. To prevent the rising to the surface during sleep the bathers place a more or less heavy stone across their groins. The proprietor of the bathing establishment, a man seventy years of age, remains during near-

*Berlin. klin. Wochenschr., 1884, 48.

ly the whole winter in the water—without garments and without stove he feels comfortable and warm, while outside snow covers the ground for four or five months in succession. His functions and his general condition are normal."

To comprehend the therapeutical value of the permanent warm bath we shall have to study the elementary effect of the warm bath.

While by the cold bath the muscles and the capillaries of the skin, and of those tissues to which the effect of the cold extends, are made to contract—a contraction which, after the irritation produced by cold has ceased, is followed by dilatation, the local anemia is changed into hyperemia—the mechanical proceeding under the topical effect of warmth runs in the opposite direction; the capillaries and arteries become dilated, as has been described in a foregoing chapter.

If a limb is left in warm water for some length of time the soft parts become swollen, quite considerable increase of volume takes place, and after removal from the bath the skin

of the submerged limb is warmer, often quite red, which discoloration disappears only after a few days.

Winternitz made experiments in the institution for experimental pathology of Professor Stricker, of Vienna, in measuring the increase of volume of the limbs subjected to baths of different temperatures. Employing for this purpose an ingenious contrivance, he was enabled to measure, on the arm suspended in water in the apparatus, increase of volume, which occurred simultaneously with the pulse-beat, and was caused by the large amount of blood driven into the arm with each systole of the heart, also changes of volume which corresponded with the larger amount of blood passing out during each interval between two systoles. He could establish the fact that the change of volume of the arm suspended in water of 8° C. could well be distinguished from the one obtained when the arm was suspended in 38° or 40° C. In the former experiment each heart systole presses only a relatively small amount of blood into the arm. The rea-

son of this can only be—the strength of the heart's action not having materially changed during the experiment—that there is a greater power of resistance of the blood-vessels (which have been contracted by the effect of cold); this power of resistance opposes the entering of the blood-wave to a certain extent.

Winternitz thus demonstrated *ad oculos* by his experiments that when some part of the body is submerged in warm water a considerably increased amount of blood passes into it with each systole, and a correspondingly large amount flows back through the veins during the intervals.

Indifferent baths, however, according to Jacob, likewise affect, to a certain degree, the circulation. As a rule the skin is from 5° to 10° C. cooler than the axilla. The normal indifferent temperature of the bath, which is 35° to 36° C., increases the temperature of the skin to almost the same degree of temperature of the internal organs, the latter sinking generally to 0.5° to 1° C., the outside temperature rising to such extent that there is often found a

difference of only 0.5° C. in favor of internal temperature. This sinking of the internal and rising of external temperature means acceleration of blood circulation, mostly accompanied by slight reduction of frequency of pulse, and is followed necessarily by relaxation of muscles, stimulation of sensory nerves, and calming of nerves of warmth and pain.

The warm bath, while it surrounds the surface of the body, or part of the body, with an equally tempered medium, does away with fluctuation as to space and time of the loss of heat, and thus acts soothing. This is of especial advantage for therapeutical purposes. It is probable that a law exists according to which soaking of the peripheral ends of the nerves reduces, and drying increases, their excitability. At least Heyman thinks it possible that the calming effect of the warm baths is superinduced by suppression of perspiration, and thus retention of moisture, which proceeding takes place during the bath, and which causes, in the first instance, soaking of Krause's end-bulbs and Meissner's tactile corpuscles; in the second

instance, cessation of molecular movements in the extremities of the nerves, and thereby general calming of the nervous system.

In some papers I cited the example of Napoleon, who, while at St. Helena, and while the monotony of his life was interrupted only by the pains he suffered from his cancerous disease, found relief when he remained for hours, or even whole days, in the warm bath.

In the paper on the effects of the continuous warm bath in arthritis, which I read before the German Medical Society, I said it is to be supposed that the permanent warm bath will prove serviceable in sciatica.

Indeed, a few months ago I had the satisfaction to learn from Dr. Fr. Grosse that he, accepting my suggestion, had had excellent results in a case of sciatica which had resisted all sorts of treatment, by placing the patient in the continuous warm bath.

Numerous physiological facts are known which support the theory that withdrawal of water excites the nerves, while gradual taking up of water (assimilation) reduces the irritabil-

ity of nerves. On this theory is based the hypodermic injection of water to produce local anesthesia.

The thermic irritation of nerves, while it lessens the sensation of pain, excites at the same time, by way of reflex action, especially in the muscle, an increased metabolism. To relieve pain in the muscles caused by fatigue, there is no better means than a warm bath. Even comparatively high degrees of temperature have a refreshing effect. The fatigue or exhaustion of muscles is caused by more than normal accumulation of the products of their function. To oxidize and eliminate these products a certain amount of metabolism is required, which change the fatigued muscular fiber is unable to perform. The specific effect of the warm bath is to afford immediate facility for oxidation. Without the warm bath this relief would be obtainable only after bodily rest for hours or days. In the evening after a battle, instead of seeking rest and sleep in bed, Napoleon would take a warm bath, to enable him to resume the march during the night and fight a second battle the

following day. On the morning of June 21, 1815, when he arrived, coming directly from the battle-field of Waterloo, in the Elysée, and dismounted from his carriage, he had to lean heavily on the arm of Caulaincourt, and he asked for a warm bath. Six days he had been on horseback nearly all the time. While he was in the bath Davout came twice to urge him to come to the assembled ministers. There was no time given for long rest; the warm bath alone stimulated him to renewed activity.

We have seen how the changes of the chemical and physical condition of tissues, the augmentation of the organic functions, the acceleration of the blood circulation, the dilatation of the vessels, the increased blood pressure depend on the specific action of the warm bath, as well as the carbonic-acid-gas bath, on innervation.

Conclusive evidence exists of the power of the continuous warm bath to remove products of inflammation and infection in the case of erysipelas of the extremities. As long as fourteen years ago I published my observations in this regard. I treated a child affected with ery-

sipelas of the leg from the knee up to the groin. The Riedel-Kraske method, which at that time was the latest treatment in use, could not be employed, since it was difficult to establish the antiseptic fence in the region of the groin. The temperature was 107° when I immersed the child's body partly in warm water; after six hours it had become almost normal. This experience of mine was invariably confirmed in every case of erysipelas of the extremities treated with the continuous bath. The method is rational, is simple, and it is difficult to see why it is not generally known.

Dr. E. C. Dent, medical superintendent of Manhattan State Hospital, Wards Island (a hospital with five thousand patients), had the kindness to give me the following information on the experience with the continuous bath in his hospital:

In acute maniacal conditions, or acute delirium states, characterized by great motor activity, the prolonged warm bath has proven very efficacious. It not only decreases the motor activity, but after some time in the bath (that

is some hours) it produces sleep. In some cases of insomnia we have found great benefit in this way without the use of sedatives.

In acute delirious conditions characterized by great restiveness, restlessness, and increased temperature, the following results have been noted: The restlessness has been reduced, sleep promoted, and the temperature has also been reduced. This is undoubtedly due to the stimulation of metabolism, as the bowels are more active and become regular. The movements are usually loose. The urine is increased in amount. We often find that tactile hallucinations are relieved. Occasionally after treatment of several days an erythema of the skin develops. This does not occur in all cases, however. If removed from the bath for a few days this condition of the skin improves. We have also noted an increase in the appetite, the patient taking food better and receiving more benefit from the food. We have also noted occasionally after prolonged treatment by this method a tendency to the formation of furuncles.

Some benefit has been derived in certain cases of melancholia with frenzy. The temperature of the prolonged bath used here varies from 98° to 100°. In some cases hot baths are given, 102° to 105°. These baths, however, are of short duration.

The length of time required in these baths varies. Some cases become quiet after a few

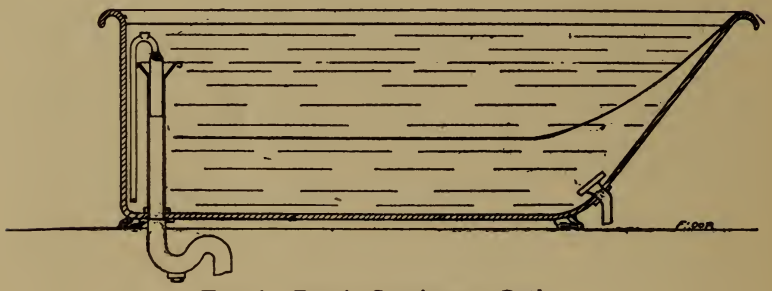


FIG. 6.—Dent's Continuous Bath.

hours, other cases require a longer treatment. In manic depressive cases, manic form, it is not unusual to leave the patient in the prolonged bath for four or five days or even weeks. There is no doubt that the prolonged bath is a great benefit, and the cases from a mental standpoint are much improved.

This form of treatment is not distasteful to patients, as a rule, very few objecting to it

FIG. 7.—Dent's Continuous Bath, Manhattan State Hospital.

after once becoming familiar with it. In fact, some patients after removal from the tubs have requested to go back.

The continuous or prolonged immersion bath, as used in the Manhattan State Hospital, has been constructed by the Kny-Scheerer Company in accordance with Dr. Dent's directions.

A fire-enameled metal bath-tub of best quality, with broad rim, each tub being six feet long and thirty inches wide, has a broad, fan-shaped inlet at the head, allowing a stream of water to flow over the neck and shoulders of the patient, who rests in a canvas cradle or hammock, suspended sufficiently deep to immerse the body of the patient as far as the neck.

As the water becomes cooler, and therefore denser, it gradually sinks to the foot of the tub, where a specially regulated outlet removes the surplus water. At the level of the water at the foot of the tub is a broad outlet that allows feces and other débris to escape.

In the tubbing-room of the hospital, where a

series of tubs is in constant operation, there is a controlling table so arranged that the tem-

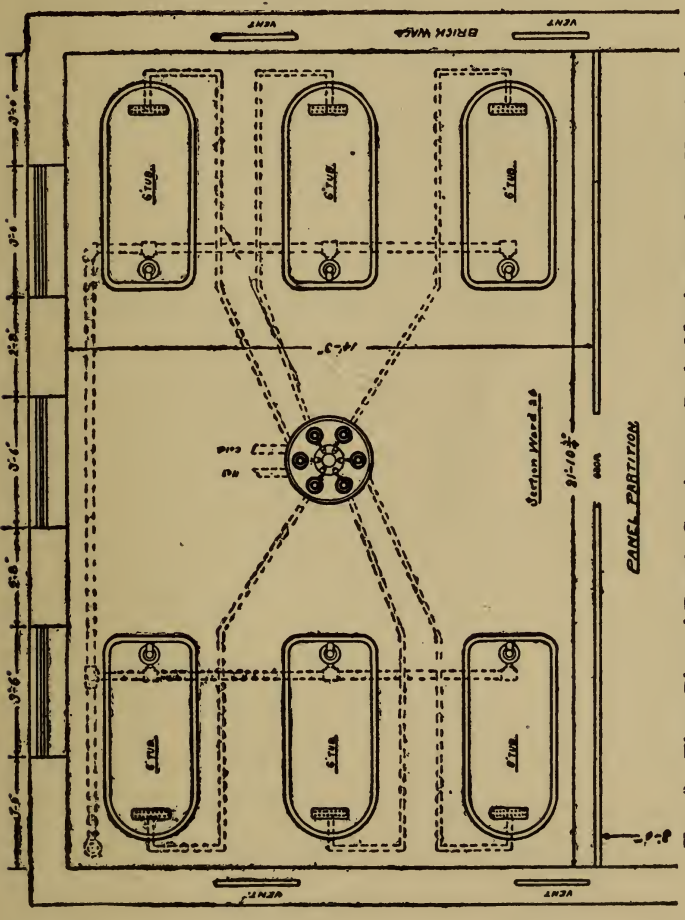


FIG. 8.—Floor Plan of Dent's Continuous Bath, Manhattan State Hospital.

perature of the water in each individual tub can be noted by the nurse in charge, and both the temperature and the rapidity of the

flow can be controlled from the thermohydrostat.

The cradle is so arranged on a series of hooks that it can be changed without removing the patient from the water. The temperature of the water is usually kept at 98.5° F. Of course this is varied according to the clinical indications. It is customary when the bath is continued longer than three days to anoint the body with lard, or some oleaginous substance of this character, to prevent water-soaking.

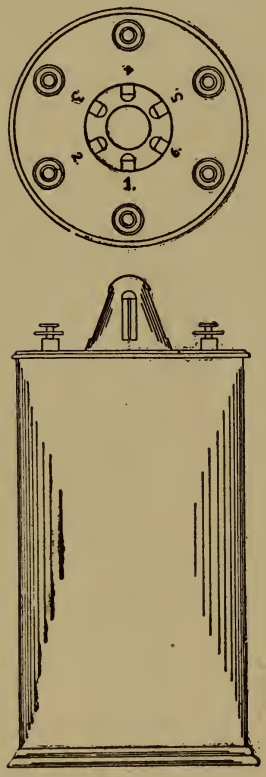


FIG. 9.—Kny's Thermohydrostat.

I myself had some experience with the continuous bath in cerebrospinal meningitis. In the year 1872–1873 we had an epidemic of cerebrospinal meningitis in New York.

While in charge of a large hospital then I attended twelve cases at one time. The mor-

tality during that epidemic was not great, certainly much less than during the present epidemic. Our experience was that medicines like iodids, bromids, and morphin, which we prescribed for a while, seemed to have no perceptible influence on the course of the disease nor even on the symptoms. We were well satisfied, however, with the effect of the continuous warm bath. Our method was to place the patient, as soon as he became delirious, into the bath-tub, the temperature of the water was kept at about blood-heat or one or two degrees less, and we left the patient in the water, with an ice-bag on the head, until he became calm, or until he fell asleep. This took sometimes two hours, sometimes as long as six hours, and the bath had in some cases to be repeated several times a day. The diet was regulated according to circumstances; in all cases we gave stimulants generously when the temperature was high, and it was on the average very high, 107° being nothing unusual. The principle in using the warm bath in cerebrospinal meningitis is to eliminate the products of inflammation and infection.